

GEORGIA INSTITUTE OF TECHNOLOGY  
OFFICE OF CONTRACT ADMINISTRATION  
SPONSORED PROJECT INITIATION

Date: 8/23/79

Project Title: TVA Wood Stove Inspector Training Seminar

Project No: A-2419

Project Director: Ms. Carol Aton

Sponsor: Tennessee Valley Authority; Chattanooga, Tenn. 37401

Agreement Period: From 7/2/79 Until 11/24/79\*  
\*Includes Mod. No. 1

Type Agreement: Contract No. TV-50547A dated 7/26/79

Amount: \$16,132

Reports Required: Comprehensive Manual for Seminar Use

Sponsor Contact Person (s):

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Defense Priority Rating: N/A

Assigned to: ERL/SRB (School/Laboratory)

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GEORGIA INSTITUTE OF TECHNOLOGY  
OFFICE OF CONTRACT ADMINISTRATION  
SPONSORED PROJECT TERMINATION

Date: Dec. 3, 1979

Project Title: TVA Wood Stove Inspector Training Seminar

Project No: A-2419

Project Director: Ms. Carol L. Aton

Sponsor: Tennessee Valley Authority; Chattanooga, Tennessee 37401

Effective Termination Date: 11/24/79

Clearance of Accounting Charges: 11/24/79

Grant/Contract Closeout Actions Remaining:

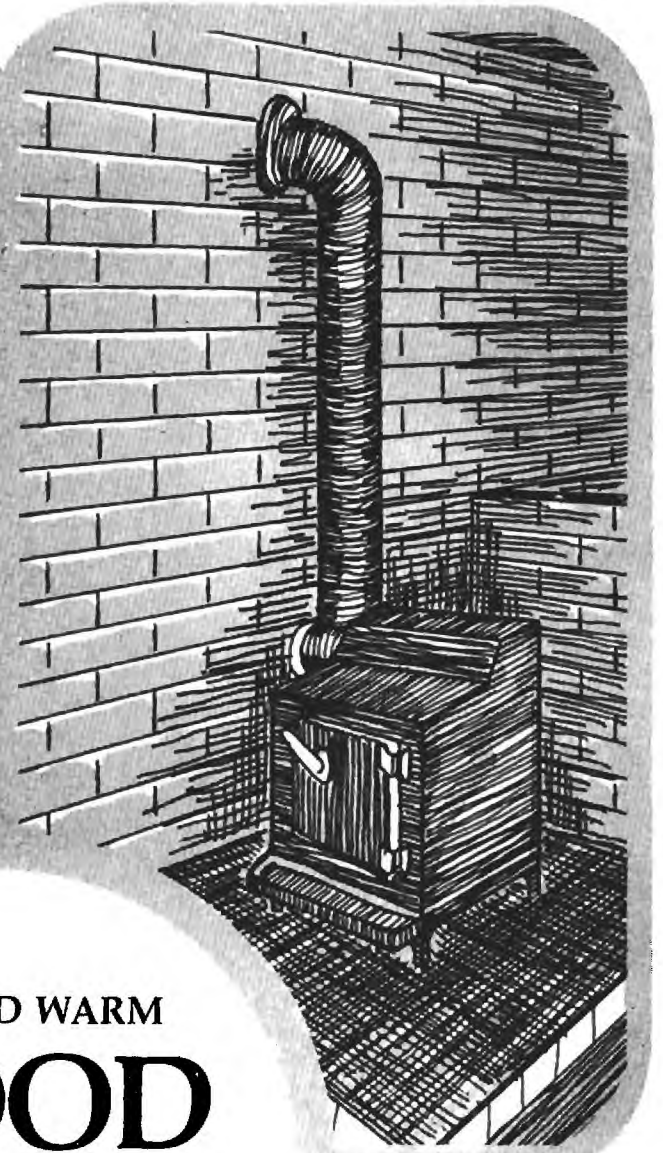
- ☒ Final Invoice and Closing Documents
- ☐ Final Fiscal Report
- ☐ Final Report of Inventions
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SAFE AND WARM  
**WOOD  
HEAT**

GEORGIA TECH  
&  
TENNESSEE VALLEY  
AUTHORITY



# **SAFE AND WARM WOOD HEAT**

**Produced by  
Georgia Institute of Technology  
Engineering Experiment Station**

**Carol Aton, Project Director  
Mike Brown  
Tom McGowan**

**With Assistance from  
The Georgia Forestry Commission**

**Funded under the Wood Heater Project by  
Tennessee Valley Authority  
Solar Applications Branch**

**Atlanta, Georgia  
September 1979**



# Foreword

Since 1973, escalating fuel prices have forced more and more Americans to rediscover wood as a heating fuel. Not only is wood a renewable resource in plentiful supply, it is also relatively cheap. In terms of heating capacity, it is estimated that a cord of hardwood burned in an airtight stove will deliver as much heat as 160 to 170 gallons of #2 fuel oil, or 260 therms of natural gas, or 6300 kilowatt hours of electricity. With hardwood selling for less than \$60 per cord in much of the U.S., substantial winter fuel cost savings can be realized.

As a result of this recent back-to-wood movement, domestic demand for woodburning stoves, for many years on the decline, is currently booming. Census of Manufacturers data show that in 1975 U.S. shipments of woodburning stove-type residential heating devices totaled 600,000 units. For the first time in more than a decade, the number shipped exceeded a half-million wood heaters; and that expanded demand for woodburners was at the expense of gas and oil heaters.

Although preliminary 1976 figures indicate a 20% decrease in unit volume shipments, it is doubtful whether fuel prices and availability will allow interest in woodburning heaters to decline as it did in the 1960s. The cost differential between wood and other fuels is boosting sales, with nearly one million units sold in 1978.

Bureau of the Census data for 1970 show that there were nearly 800,000 occupied housing units in the U.S. in which wood was used as the *principal* heating fuel. Of this number, almost one-third were located in the South Atlantic states.

For the most part, owners of woodburning heaters can anticipate many years of adequate fuel supplies. USDA Forest Service data indicate the area of commercial timberland in the U.S. to be about 500 million acres, a volume which is expected to remain relatively stable ( $\pm 5\%$ ) into the 21st century.

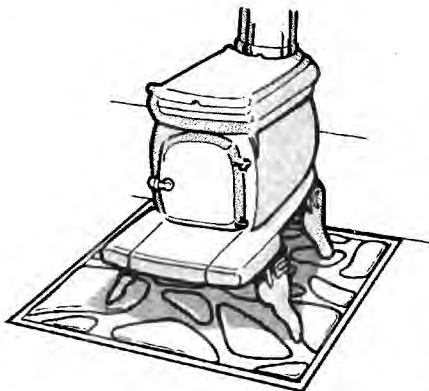
In the Southeast, the area of commercial forestland is 140 million acres. The output of fuelwood from this land was 3.5 million cords in 1976, nearly twice as much as the 1.8 million cords produced back in 1970. During the first five decades of this century, fuelwood consumption had dropped sharply as oil, gas, and electricity were substituted for domestic heating and cooking. Recently, however, considerable demand for fuelwood has developed in both rural and urban areas for secondary heating. Consequently, as heating costs rise and wood becomes a more economical fuel, the use of woodburning stoves will continue to expand.

# Buying Your Stove System

## Know What You Want

Before switching to wood heat, consider the lifestyle changes you will have to make. Are you willing to put in some hard but enjoyable effort in gathering the wood? Is a high, medium, or low heat setting sufficient for you rather than the precise temperature control of fuel-guzzling conventional systems? Do you want the cheery warmth of a woodstove even if it means intermittent stoking, cleaning the flue, and emptying ashes?

Wood heat can save you money especially if you cut your own firewood. It can also provide a backup during midwinter power outages as well as a warm conversation center where family and friends inevitably gather around. But there definitely is manual labor involved with woodstoves, and a *fire-safe lifestyle is a must*. Also remember that a woodstove installation is nearly permanent, so if you rent or move every few years, the stove will probably remain behind.

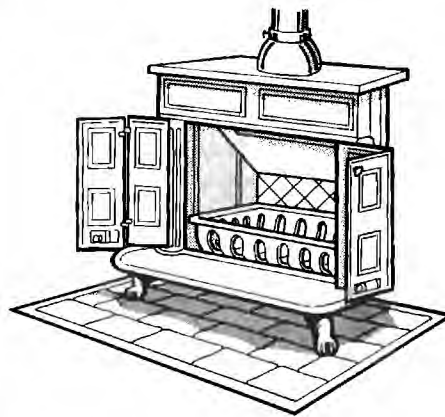


Box stoves may be square, round, oval, or pot-bellied. Unlike Franklins they don't have doors for viewing the fire. Box stoves are also very drafty, so control of the fire is limited to size and frequency of refueling. Box stoves are for occasional use with constant attention.

## Know What You Need

### TYPE

There are three basic types of woodburning stoves — open, box and airtight. Open stoves are for watching the fire; box stoves are for occasional heating of small areas. But if you are serious about supplementing a regular heating system and cutting the family fuel bill, you should look at airtight stoves. (Note that some open stoves are convertible to airtight with closely-fitted doors.) Air leaks are almost always detrimental to combustion because they occur at the wrong place and the wrong time, cutting down your ability to control the heat output. The only practical test is a visual inspection. Look for cracks around the door or other movable exterior parts and around joints of the various fixed parts of the stove.

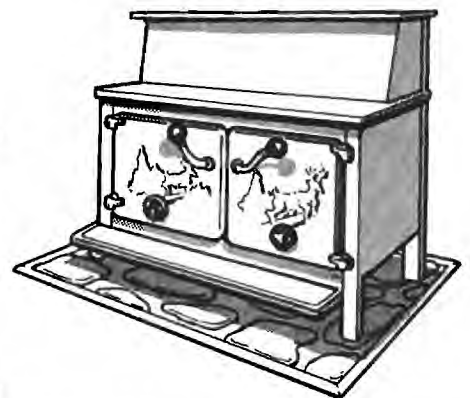


Open stoves, also known as Franklins, attempt to combine the efficiency of an enclosed firebox with the romance of dancing flames. Open stoves are much more efficient than regular fireplaces, but not as efficient as airtight stoves. They require frequent stoking to obtain a steady heating rate and cannot keep a fire overnight. A tightly constructed house can cause an open stove to smoke by restricting its air supply. Most open stoves are for people who want to keep warm while watching the fire. Note: Some open stoves are convertible to airtight with closely-fitted doors.

According to HUD regulations, only direct-vented woodstoves can be installed in mobile homes. That is, combustion air must be vented directly from outside the home to the firebox via special ductwork to prevent smoking inside the home. Houses specially built to reduce air infiltration may also have smoking problems if direct-vented stoves are not installed.

### EFFICIENCY

Other things being equal, more efficient stoves use less wood to do the same heating job. Airtight doesn't automatically mean efficiency. Overall stove efficiency is a combination of how much heat is generated from the wood (combustion) and how well that heat is transmitted to the room (heat transfer). Good combustion requires plenty of oxygen and very high temperatures in the combustion zone. Good heat transfer requires minimum air and removing heat from the combustion zone. So the key factor is optimum use of inlet air.



Size and shape can vary, but airtight means no air can get into the combustion area except where it's designed to get in — at the air inlet dampers. This makes them more efficient and more controllable than open stoves or box stoves. Airtights are for heating large areas over long periods of time with minimum supervision.

Stove manufacturers try to make their stoves more efficient with a myriad of designs using secondary air inlets, preheated inlet air, thicker walls, large fireboxes, baffles for turbulence, and various flow patterns. Not all of these really increase efficiency. But various stove-testing facilities are being set up around the country, so unbiased efficiency ratings should be easier to come by in the near future. Jay Shelton discusses stove design and efficiency in his *Woodburners Encyclopedia*. His preliminary tests indicated that average efficiencies range from 40% for non-airtights to 65% for airtights with six feet of stovepipe. Higher efficiencies being quoted by sales brochures are most likely measured under ideal conditions such as oven-dried fuel and controlled chimney draft.

## SIZE

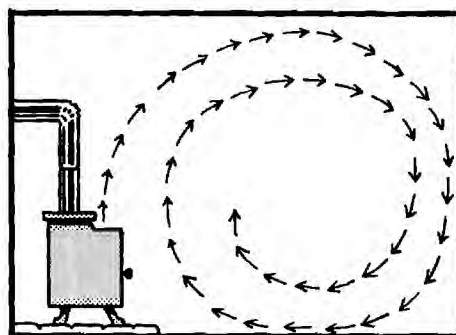
Your stove should be sized to supply the heat you need — no more, no less. Average values for heat output of typical stoves are:

Small box	20,000 Btu/hr
Large box or open	30,000 Btu/hr
Small airtight	40,000 Btu/hr
Large airtight	60,000 Btu/hr

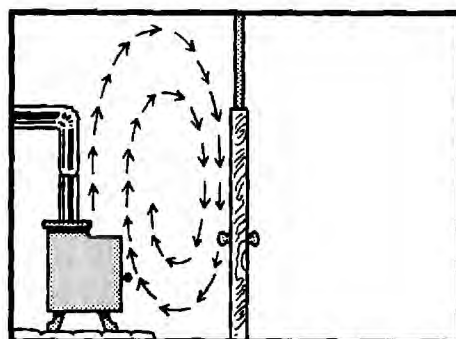
But how much heat do you need? This requires a heat loss calculation taking into account outdoor temperature, building construction, floor plan, and the indoor temperature you consider comfortable. Estimate your heat needs by one of the methods below.

### Method A

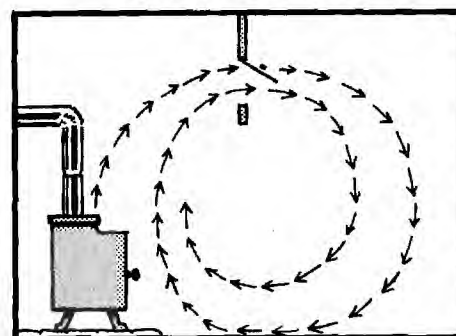
1. Decide what room or rooms you want to heat with the woodstove. The rooms should be adjacent, with air flow patterns that allow for good heat circulation.
2. If you have a warm air heating system, count the number of supply registers in the rooms. Do not include cold air return registers.
3. Multiply by 6000 to get heat needs in Btu per hour.



ONE LARGE ROOM



TWO SMALL ROOMS  
W/ CLOSED DOOR



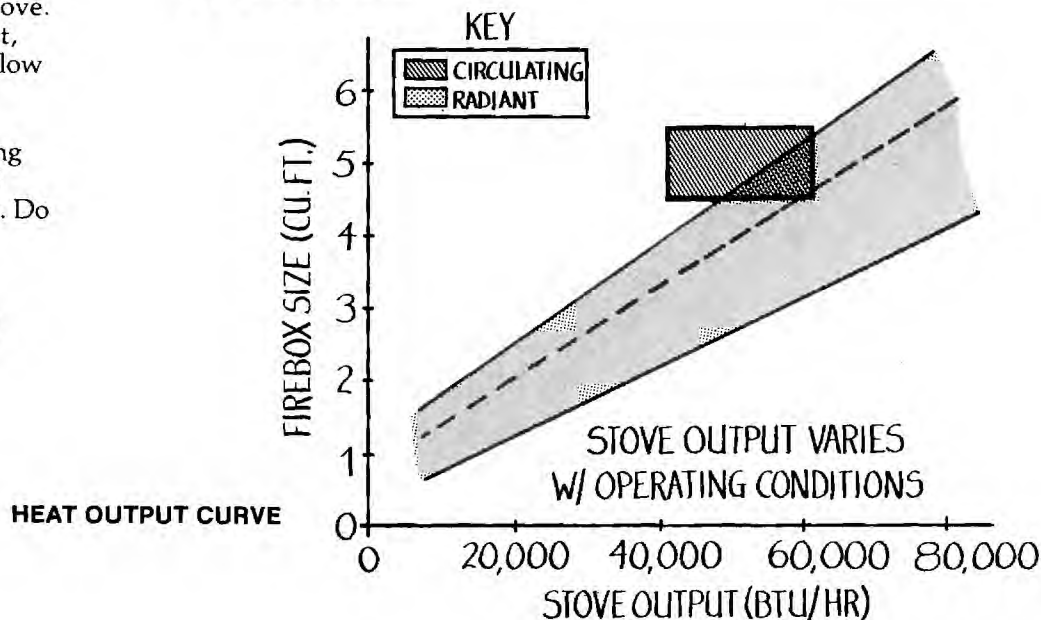
TWO SMALL ROOMS  
W/ OPEN DOOR  
AND UPPER REGISTER

### Method B

More accurate numbers can be obtained if you know the actual Btu per hour of your present heating system.

1. Read the *output* off your present furnace identification plate. For electric furnaces, multiply kilowatt output by 3412 to find Btu per hour. For space heaters, add up the individual output specifications in Btu per hour.
2. If you have uninsulated ducts in the attic or crawlspace, multiply by 0.75. If the ducts are insulated, multiply by 0.90.
3. Add up the area of the rooms you want to heat with the stove and divide by the total area of your house. (Do not include rooms that are not presently heated.)
4. Multiply the number found in step 3 by the number found in step 2 to get your heat needs in Btu per hour.

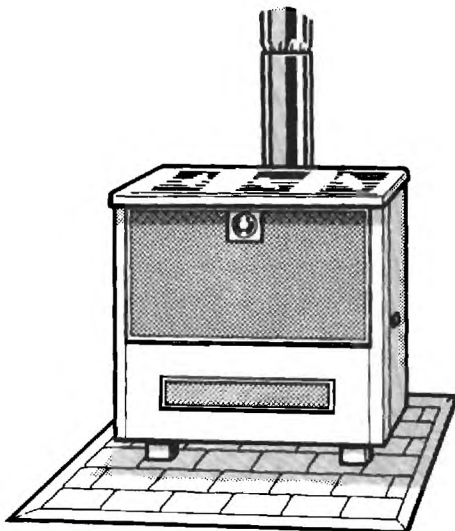
Now you know your heat needs, either by Method A or B. Measure the firebox and compare your heat needs with the heat output curve below. Choose your stove accordingly. (Remember you used the homebuilder's numbers, so if you've added storm windows and insulation or more rooms, you will want to adjust your heat needs down or up.) Compare notes with a good stove dealer who knows how well his stoves work in present installations.



## DESIGN FEATURES

Design features do not affect efficiency of the stove, but should be kept in mind for your own convenience.

- An ashpan makes removal of the ashes simpler; without one you must shovel out the ashes.
- A circulating stove is safer for households with small children because hot stove surfaces are covered by an outer jacket; also, required clearances to furniture and walls are less. A radiant stove, on the other hand, gives off most of its heat as infrared radiation, considered to be more comfortable than heated air by some.



**CIRCULATING STOVE**

- Door location and size determines how easily the wood fuel can be loaded.
- Firebox size determines how big your wood pieces can be. The larger the pieces the less cutting you'll have to do.
- Cast iron versus plate steel is largely a matter of preference; cast iron cracks, plate steel warps, and both are susceptible to corrosion. But neither has been proven more efficient than the other. Top quality tight-fitting construction rather than material is the key to a good stove.
- There are two types of damper controls for "automatic" woodstoves, the all-or-none versus the gradual. Each has its own operating characteristics; but average temperatures of the room with comparable systems remains the same.
- You can't go wrong with a flat black stove; but other colors including white can have high heat transfer depending on pigments and surface texture. Just be sure to avoid shiny metallics, both for stoves and for stovepipes.

- Liners, firebrick or steel, extend the life of the firebox and are much less expensive to replace than the stove itself.

## CHIMNEY

The chimney is a critical part of your woodstove heating system. It not only carries smoke out of the house, but also pulls in the air needed for good combustion. Whether to use a masonry or prefabricated metal chimney is up to you. Size and safety are more important. Unless the manufacturer specifies otherwise, use a chimney diameter equal to that of the flue pipe collar on the stove. An oversized chimney can cause excessive water and creosote condensation.

If you plan to use an existing chimney, inspect it thoroughly. If you plan to install a new chimney, do it properly. A chimney that meets fire and building codes will ensure a stove system that heats your home rather than burning it down.



# Installing Your Stove System

## Stove Placement — Where & Why

Your stove should be located in a frequently used area such as the living room, family room, or den. You can stay warm and comfortable for most daily activities and still keep the bedrooms cooler for sleeping. Choose a room at least 12 times the size of the stove.

The best place for a stove is in the center of the room where it can radiate heat in all directions. The worst place to put a stove is in a closet or alcove. Practically speaking, stoves are usually placed in the middle of an outside wall. This makes venting the stove much easier. *But it requires proper clearance between stove system surfaces and their surroundings to keep your home fire-safe.*

## Some Materials Burn, Some Don't

A woodstove gives off radiant and convective heat. If a combustible material is too close to the stove, it will become hot and catch on fire. For example: wood studs, even though covered by noncombustible sheetrock, can burn at abnormally low temperatures if exposed to constant heat from a woodstove. Clearances are specified by safety codes to prevent overheating of combustible materials by keeping them at a distance. Shielding combustibles from the heat reduces the required clearances. Following these recommendations closely will ensure a safe installation in your home.

A wall or ceiling is considered to be noncombustible if it is made entirely of masonry (brick, concrete, concrete block, plaster on brick, stone) or other noncombustible materials such as sheetmetal. Combustible walls include all that contain wood framing. This means plaster and sheetrock walls on wood lath or wood studs. Nearly every wall and ceiling in residential buildings contain wood. *If you are not sure, assume the wall or ceiling is combustible and maintain proper clearance.*

A floor is considered noncombustible if it is concrete, slab on grade design, or solid concrete that has steel or concrete, BUT NOT WOOD, supports. An existing masonry hearth is noncombustible if there are no wood forms left in place below it and if stove placement will allow at least 18" of hearth in front of the loading door.

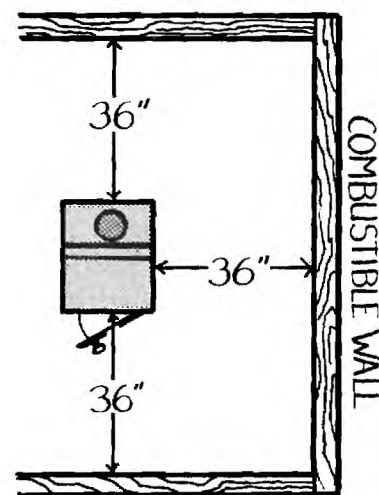
All wood floors, carpets, and synthetic flooring materials are considered combustible and must be protected in an approved manner. Other combustible materials include furniture, draperies, and newspaper. Keep these well away from the stove.

## Clearances — A Must for Safety

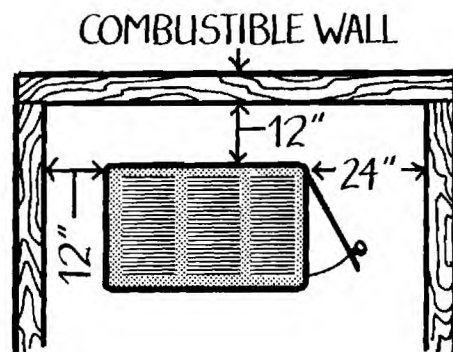
The following information is based on NFPA Booklet 89M. If the clearances differ from manufacturer's instructions, use the larger clearance.

### UNSHIELDED WALLS AND CEILINGS

Radiant stoves (not enclosed in a sheetmetal cabinet) require 36" clearance on top and on all sides. Circulating stoves (with a sheetmetal cabinet) require 36" clearance to combustibles above the cabinet, 24" in front of the loading door, and 12" from the back and other sides.



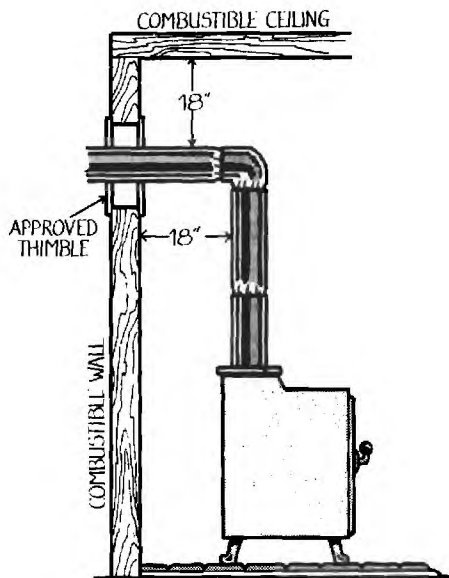
UNSHIELDED RADIANT STOVE



UNSHIELDED CIRCULATING STOVE

The stovepipe must have 18" clearance to combustible walls and ceilings, measured at right angles to the pipe.

No clearance is needed for stoves or pipes to noncombustible walls. However, it is good practice to allow 6" or more for good air circulation and dissipation of heat.



### UNSHIELDED STOVEPIPE

### UNSHIELDED FLOORS

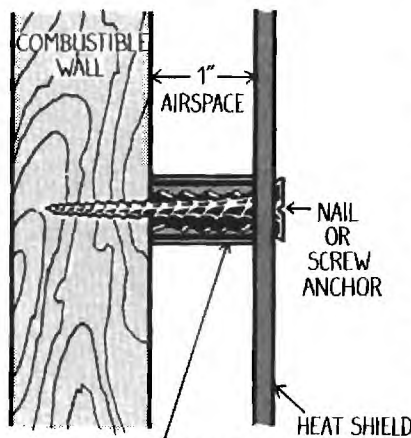
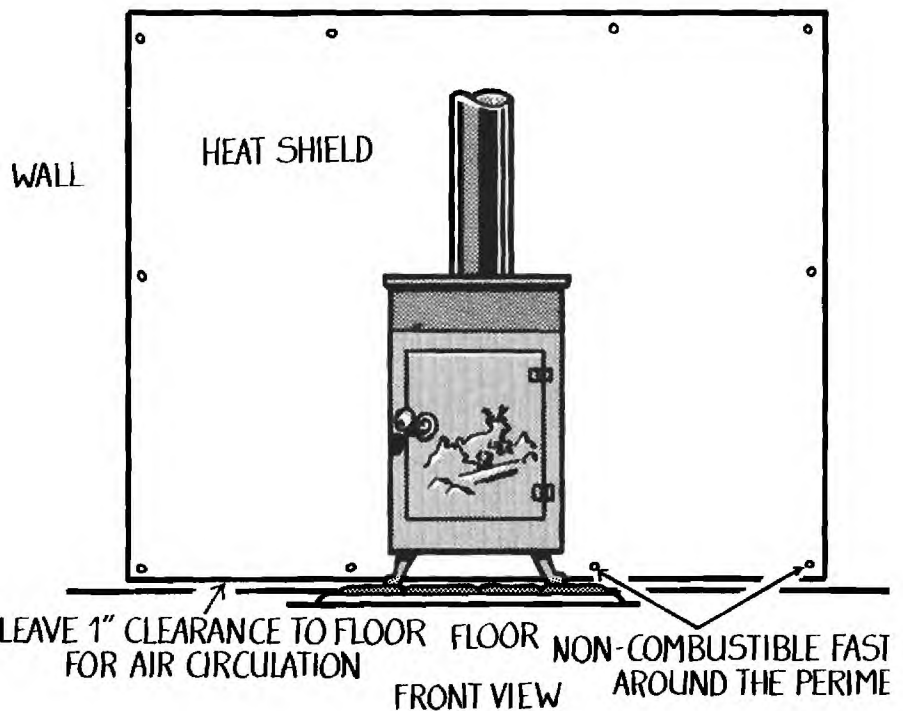
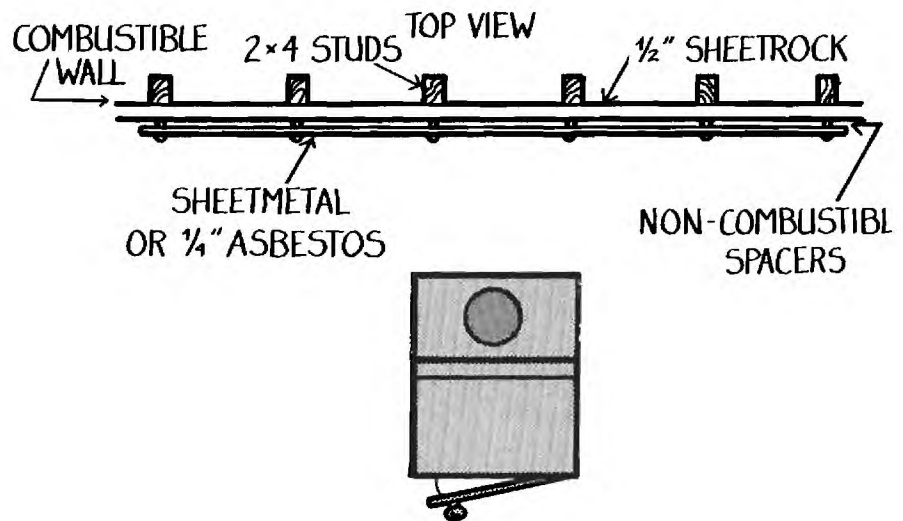
All stoves must have legs at least 4" high to allow air circulation underneath no matter what floor they are mounted on.

The only base a stove can be installed on without special shielding is a noncombustible floor or hearth. According to the National Building Code, it should extend at least 18" in front of the loading door to prevent damage from sparks, embers, ash, or radiant heat. It should also extend 6" or more on the three remaining sides.

### Reduced Clearances With Heat Shields

Woodstoves may be placed closer to a combustible material that is shielded in an approved manner.

The two most common methods of heat shielding are 28 gage or thicker sheetmetal (galvanized steel, aluminum, copper) and 1/4" asbestos millboard (a soft material that can be cut with a knife or saw, not rigid asbestos cement board). These materials must be spaced one inch out from the wall or ceiling. That is, they must be anchored to the combustible surface so that a 1" air space exists between the sheetmetal or asbestos and the combustible material. This allows air to flow freely, removing heat by convection and ensuring a low enough temperature to avoid catching the wall on fire.



1" NON-COMBUSTIBLE SPACER SUCH AS STACKED WASHERS, SMALL DIAMETER PIPE, TUBING, OR ELECTRICAL CONDUIT. **DO NOT** USE FASTENERS DIRECTLY BEHIND STOVEPIPE OR STOVE.

Sheetmetal or asbestos millboard nailed to the wall without this airspace offers **no** protection and cannot be considered a heat shield. The same applies to brick stacked or mortared against a combustible wall and to "Z-brick" or other veneer brick and stone coverings. If these materials are mounted on sheetmetal or millboard and if the 1" minimum spacing to the wall is maintained, then they are equivalent to using 1/4" asbestos millboard protection.

Materials for heat shields can be obtained locally at hardware, building supply, and sheetmetal shops. Prefabricated heat shields are available through stove and fireplace dealers. These come in a variety of finishes and sizes. They usually incorporate a metal shield with an insulated liner on the back. While these panels are more expensive, their insulation will help reflect more heat to the room. Several other types of protection may be used; NFPA Booklet 89M covers the lesser used materials.

### Shielded Walls and Ceilings

Table I shows clearances using heat shields on walls and ceilings. These clearances are also depicted in diagrams.

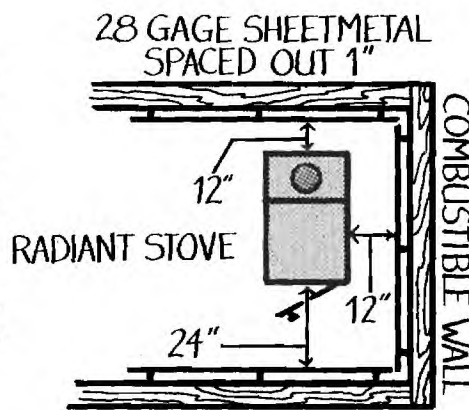
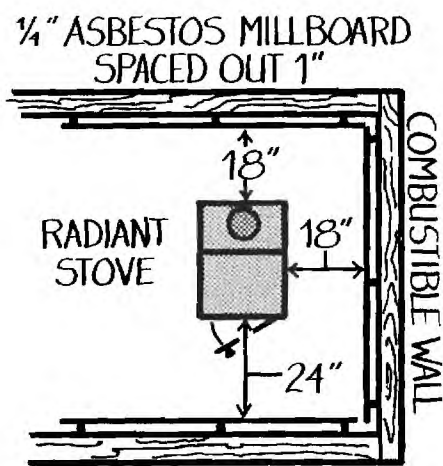
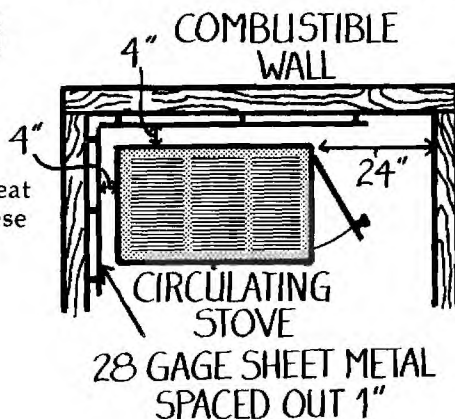
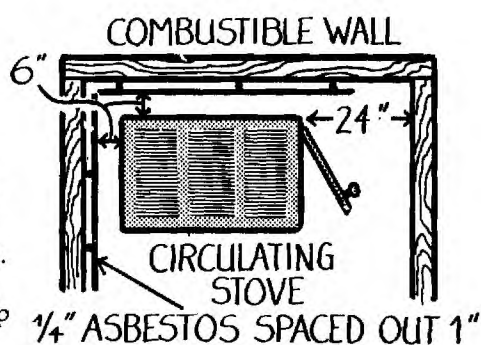
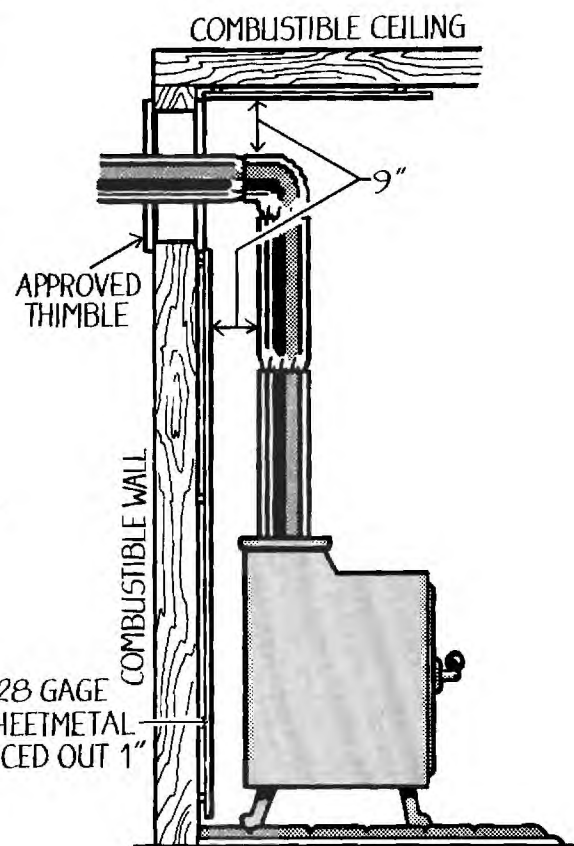
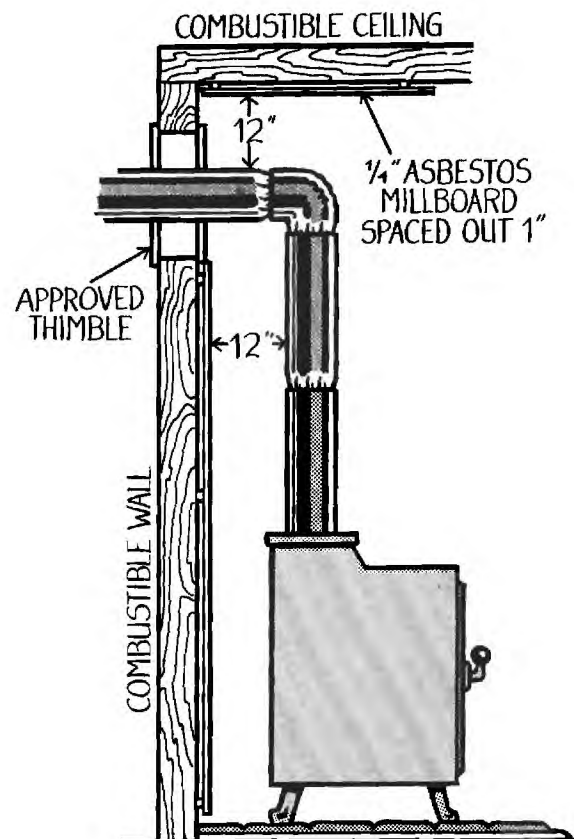


TABLE I  
Clearances to Walls and Ceilings with Heat Shields

Type of Heat Shield Protection	Radiant Stove	Circulating Stove	Stovepipe
1/4" asbestos millboard spaced out 1"	18"	6"	12"
28 gage sheetmetal spaced out 1"	12"	4"	9"

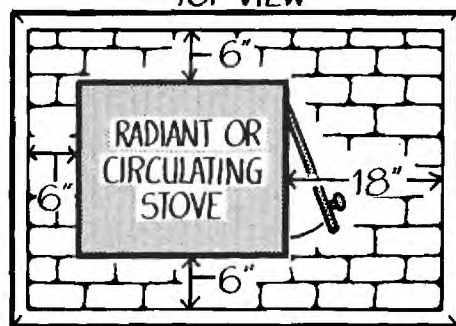
### Notes:

1. These clearances are from the side of the stove or stovepipe to a parallel combustible surface.
2. Use these clearances or those contained in the manufacturer's instructions, whichever is greater.





## MINIMUM STOVEBOARD OR HEARTH DIMENSIONS TOP VIEW



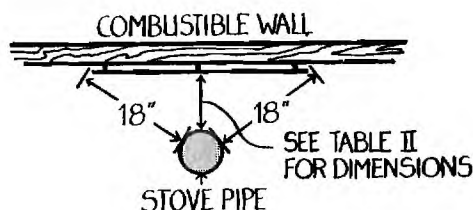
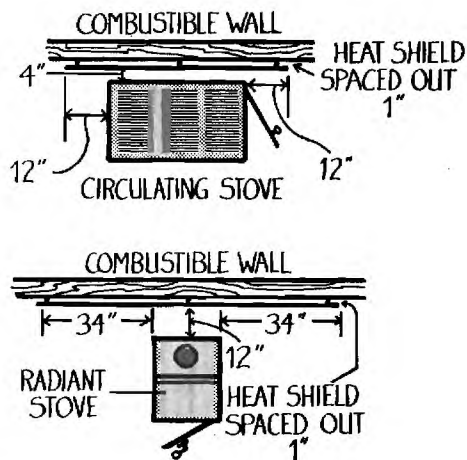
## STOVEBOARD OR HEARTH

### Shielded Floors

All combustible floors must be protected. A floor shield may be made of 24 gage or thicker sheetmetal or a prefabricated stoveboard or hearth shield.

Brick, slate, or patio stone may be used but must be installed on top of a sheetmetal or asbestos base. The base should extend 18" in front of the loading door to prevent damage to the floor from sparks, embers, ash, or radiant heat. The base should extend 6" or more on the three remaining sides.

Maintaining 18" of noncombustible base in front of the loading door is a common sense way to keep ashes and embers off the combustible floor.

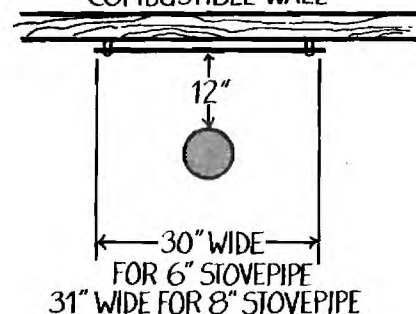


### SIZING HEAT SHIELDS

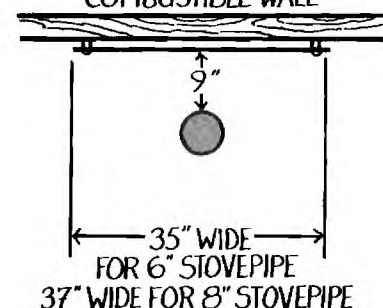
The asbestos millboard or sheetmetal spaced out from the wall should extend 12" past the edge of the stove in height and width for circulating stoves. For radiant stoves, the heat shield should extend 34" above and to either side of the cabinet. These are minimum dimensions when the stoves are placed as close as the code will allow. If the stove is placed farther from the wall, the width and height of the shield can be found by measuring from the side and top edge of the stove to the wall: 12" for circulating stoves and 36" for radiant stoves.

The heat shield must be centered behind or above the pipe to protect the wall or ceiling. Table II shows minimum heat shield widths for installation behind stovepipe.

## MINIMUM WIDTH OF HEAT SHIELD AT MINIMUM CLEARANCE FROM WALL 1/4" ASBESTOS MILLBOARD SPACED OUT 1"



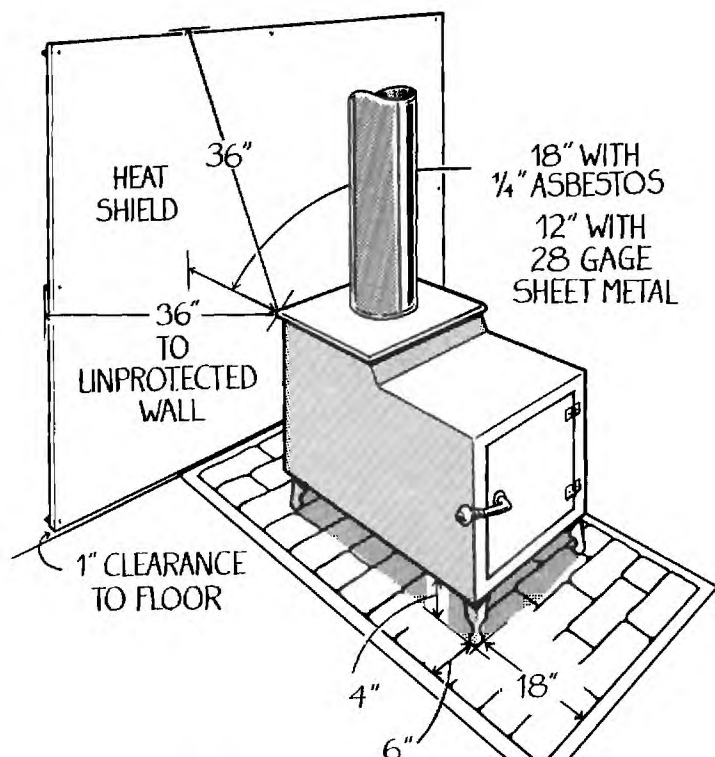
## 28 GAGE SHEETMETAL SPACED OUT 1"



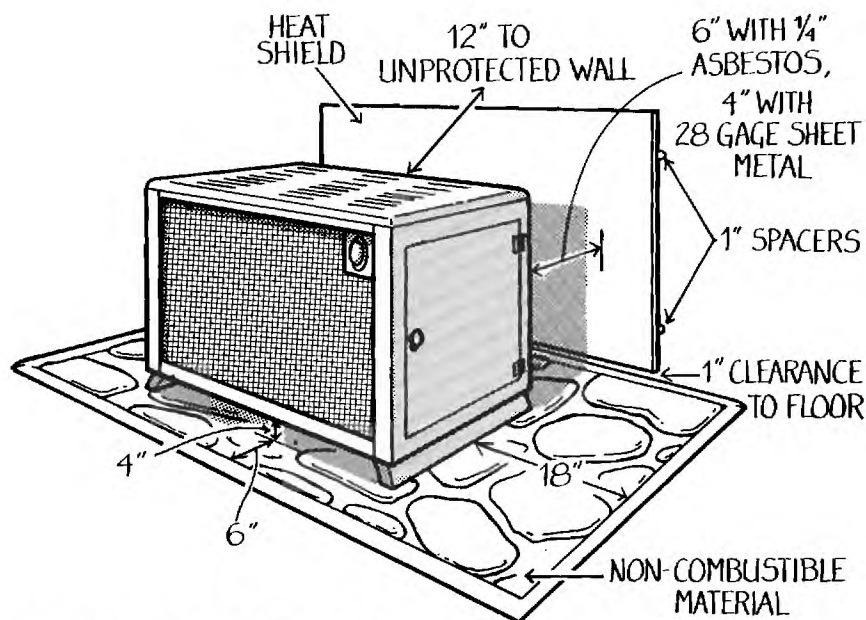
The summary diagrams show the overall relationships discussed above. The larger the distance between the stove or pipe and the wall, the smaller the heat shield needs to be. For further information, contact your local building code inspector.

**TABLE II**  
Minimum Heat Shield Widths

Type of Protection	Distance of Pipe to Heat Shield	6" Single Wall Pipe	8" Single Wall Pipe
1/4" asbestos millboard spaced out 1"	12"	30"	31"
28 gage sheetmetal spaced out 1"	9"	35"	37"



**SUMMARY DIAGRAM—RADIANT STOVE**



**SUMMARY DIAGRAM—CIRCULATING STOVE**

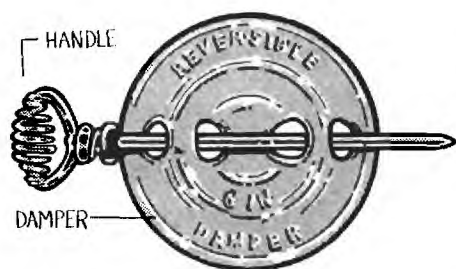
## Assembling the Stovepipe

The chimney connector or vent connector is commonly known as the "stovepipe." This single wall metal pipe is NOT a chimney; it connects the stove to the chimney. Blue or black steel stovepipe of 24 gage or thicker is the most common material and usually costs the least. Use either 6" or 8" diameter pipe, the same diameter as the pipe outlet on the stove. The stovepipe should be as short as possible for safety reasons, but installations with five feet or so of pipe are acceptable. The extra length raises the efficiency of the woodstove by reclaiming some heat from the stack gases before they enter the chimney.

It is usually best to start from the heater end. Always install the crimped end of the elbow or straightpipe **towards** the heater. This allows creosote and water to drip back to the heater. Use non-adjustable elbows where possible; they are cheaper and last longer. Cut the pipe sections to length with metal shears.

Stovepipe is usually shipped flat, in 2' lengths. In order to assemble each length, the seams are squeezed together while pressing down on the pipe. When a snapping or clicking sound is heard, the joint is made. Start at one end, pressing and squeezing as you proceed to the other end. Occasionally the stovepipe is defective, and a tight joint cannot be made. Discard the stovepipe or break the joint and trim the male side of the joint with sheetmetal shears until it fits properly.





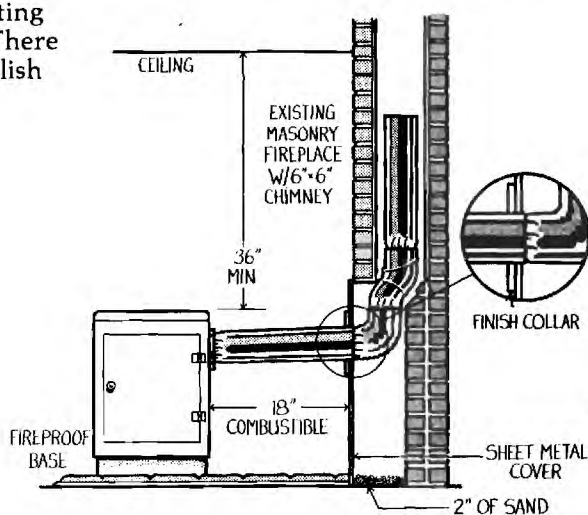
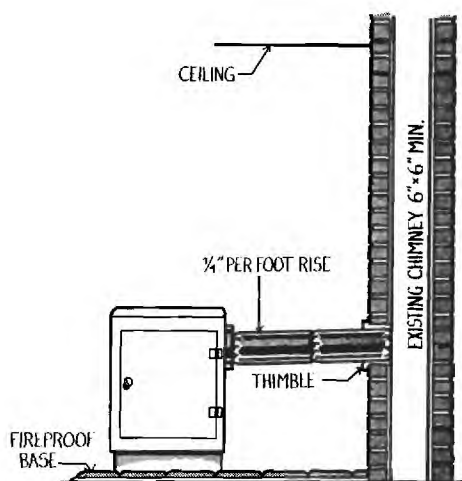
Next, install the damper. A damper is a rotating plate, usually made of cast iron, that controls the draft on the stove. Dampers are a necessity for proper operation of non-airtight stoves. On airtight stoves they allow better control of combustion and can be used to control chimney fires. Install the damper in the straight run of stovepipe closest to the stove. Drill a  $\frac{1}{4}$ " hole through both sides of the pipe, position the damper inside the pipe section, insert the handle and turn to lock it to the plate. Some stoves have a built-in outlet damper and do not require a second one in the stovepipe.

Connect the pipe sections in proper order. When you are satisfied with the fit, install three sheetmetal screws at each joint and at the connection of the collar at the heater.

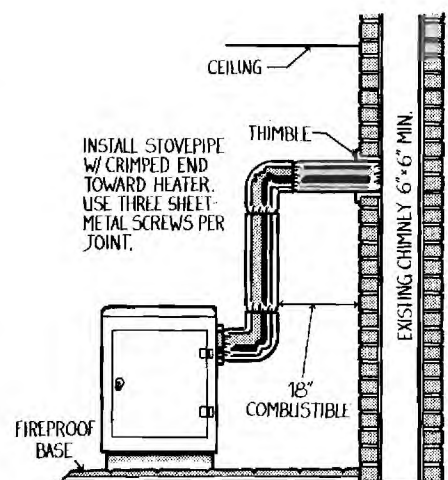
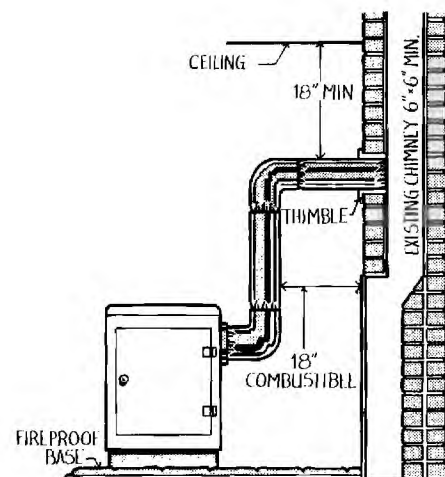
## Venting Into a Fireplace

Many people convert an existing fireplace to woodstove use. There are two easy ways to accomplish this.

The first method is to insert the stovepipe through the fireplace opening. Spread a 2" layer of sand on the floor of the fireplace to absorb condensation, rain, and creosote. Take a piece of sheetmetal big enough to completely cover the fireplace opening and cut a hole for the stovepipe. Insert the pipe and secure the sheetmetal to the masonry of the fireplace; seal the edges with furnace cement or stove putty. It is best to use an elbow and a short vertical length of pipe inside the chimney to reduce soot and creosote accumulation on the floor of the fireplace. It also keeps the fireplace damper from closing.



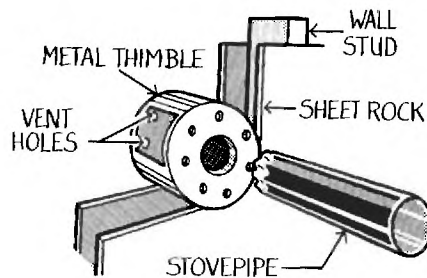
The second method is to insert the stovepipe above the fireplace opening. Seal the opening with brick or secured sheetmetal, or seal the fireplace damper closed. Cut a hole through the brickwork above the fireplace, and install a ceramic or metal thimble. If the hole passes through a wood-framed wall section (sometimes used over the fireplace mantel), a ventilated or noncombustible thimble is required instead.



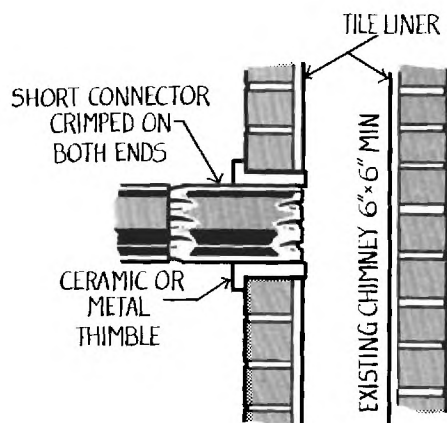
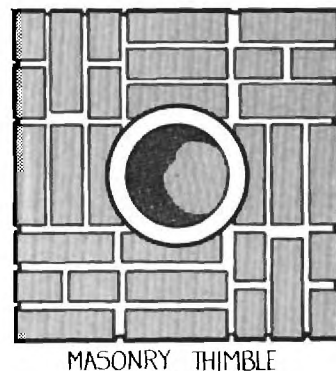
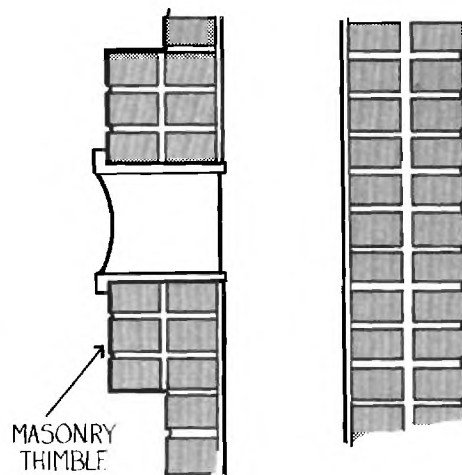
Be sure to leave at least 18" clearance between the top of the stovepipe and the ceiling. Placing the center of the hole two feet below the ceiling will assure proper clearance for 6", 8", and 10" stovepipe.

## Through the Wall With Thimbles

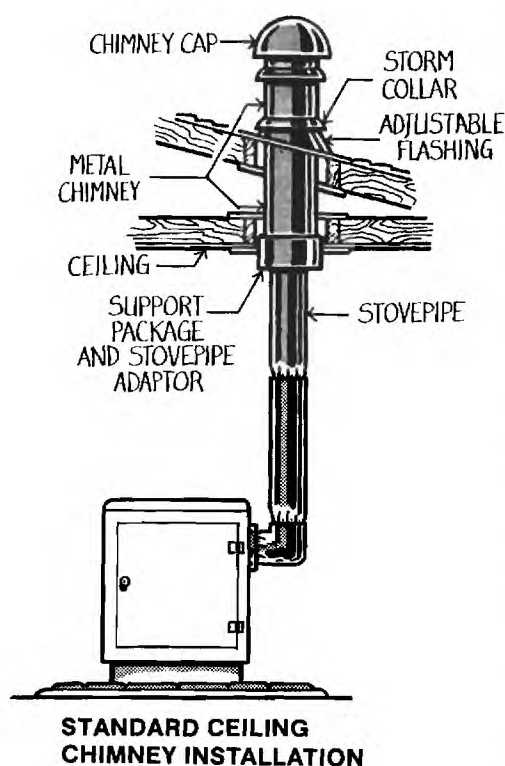
A metal or ceramic thimble is used when passing through noncombustible walls. It should be permanently cemented into the chimney wall to the inner face or liner, but not beyond. A short section of stovepipe, crimped on both ends, is pushed into the thimble and secured with furnace cement or stove putty. The stovepipe should extend as far as possible into the thimble, but not stick out into the chimney.



If you must vent through an interior or exterior wall that is combustible, either convert from stovepipe to Class "A" metal chimney or use a ventilated thimble. This is a metal flange that allows air circulation to prevent heat buildup. The thimble must be at least 12" larger than the stovepipe, or 18" for a 6" pipe and 20" for an 8" pipe. A non-ventilated thimble may be used with a fire clay or metal thimble surrounded by brickwork at least 8" wide on all sides. A final way to pass a single wall stovepipe through a combustible wall is to cut away the combustible material to provide 18" of clearance all around the stovepipe.







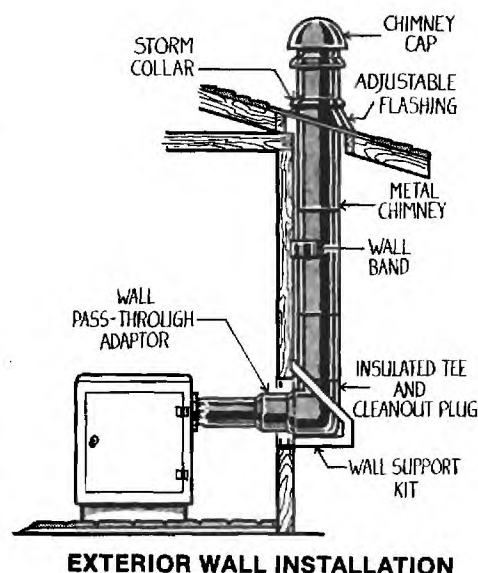
## Up and Out With Chimneys

If you do not have a chimney, or have one in poor repair, a new chimney may be the best solution. Chimneys used with woodstoves must meet Class "A" standards. A Class "A" masonry chimney must be 4" brick with a tile liner or 8" of brick. Double-wall insulated pipe or triple-wall pipe, both with stainless steel liners, also meet Class "A" requirements. These are sometimes referred to as "prefabricated chimneys" or "UL tested all-fuel chimneys." The metal chimneys are usually cheaper than their masonry counterparts and are more adaptable to installation in an existing house. We will only discuss metal chimney installation; masonry chimneys require the work of an experienced mason.

When the stovepipe extends to the ceiling, a support package and stovepipe adaptor are installed at the ceiling, and one or more sections of metal chimney are added to the rise above the roof. Stack the sections and lock them securely with a clockwise turn. Usually a 2" clearance is required between the metal chimney and wood framing in the ceiling and roof. Follow the manufacturer's instructions closely.

In rooms with cathedral ceilings, the roof and ceilings are combined, and a special adjustable collar is needed to support the weight of the chimney on the rafters.

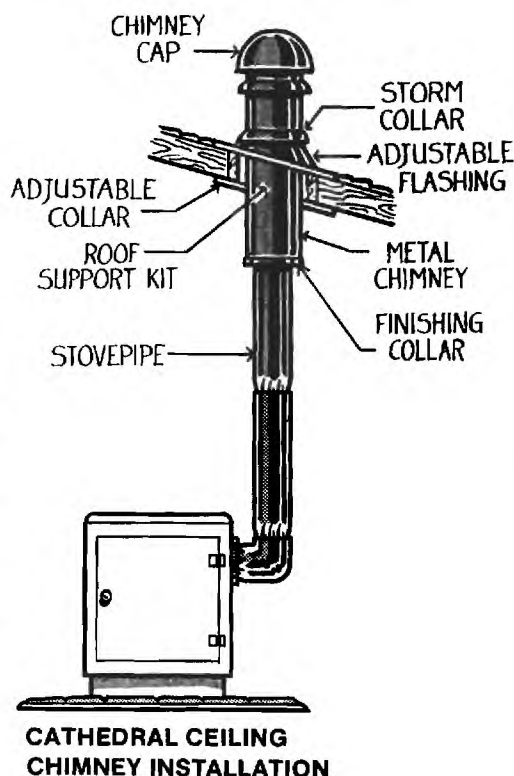
The third common type of installation is a through-the-wall arrangement. This requires a support kit composed of an insulated tee with clean-out plug and a wall bracket. At the roof line an adjustable flashing and storm collar are used to keep rain out.



**TABLE III**  
Minimum Chimney Heights

Roof Slope*	Height above roof for ridge 10 feet or more from chimney
FLAT	3'0"
1/12	3'0"
2/12	3'8"
3/12	4'6"
4/12	5'4"
5/12	6'2"
6/12	7'0"
7/12	7'10"
8/12	8'8"
10/12	10'4"
12/12	12'0"

\*Roof slopes are given in feet of rise per 12 feet of run. A 6/12 slope rises 6 feet per 12 feet of horizontal run.



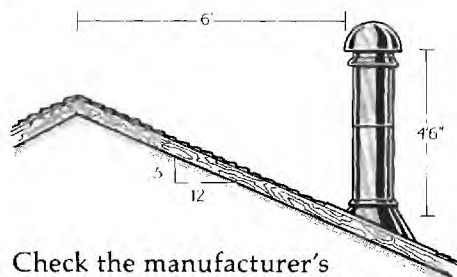
Chimney height is critical to creating proper draft and preventing downdrafts during windy weather. The code requires 3 feet minimum height, plus at least 2 feet more than any part of the roof within 10 feet measured horizontally. Table III shows the height above the roof required for various roof slopes.

The chimney height over the roof given in the table is for chimneys 10 feet or more from the roof ridge. If the ridge is closer, the proper height can be calculated by the following formula:

$$(\text{Roof Slope} \times \text{Distance to Ridge}) + 2'0'' = \text{Required Chimney Height}$$

For example, a chimney on a 5/12 sloped roof, located 6 feet from the ridge requires:

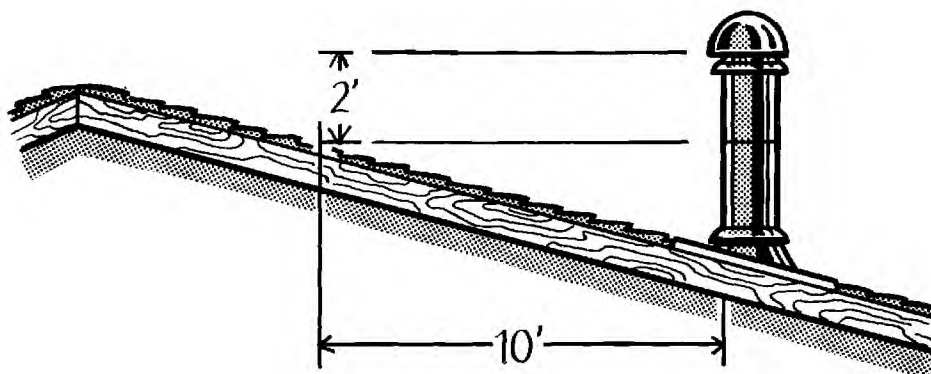
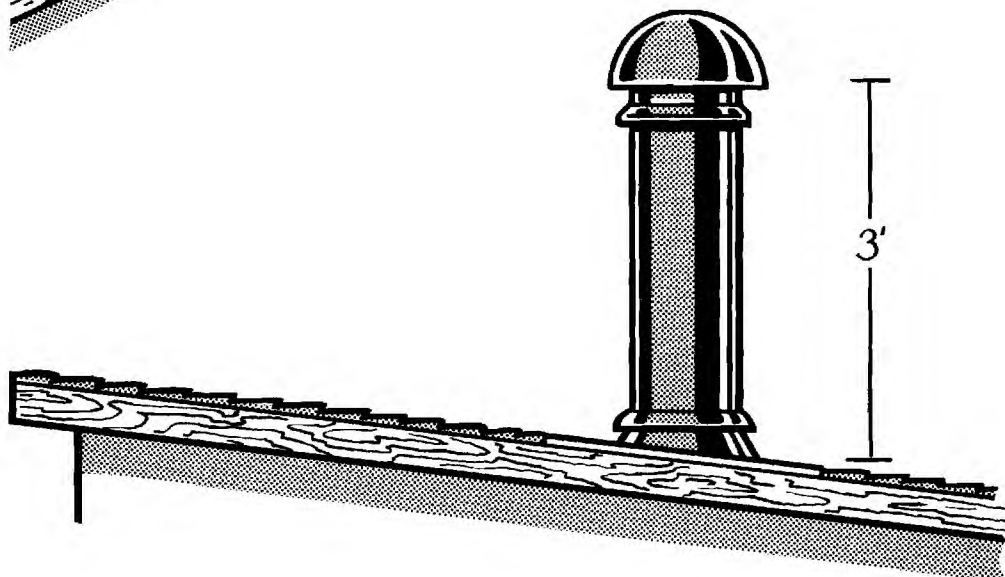
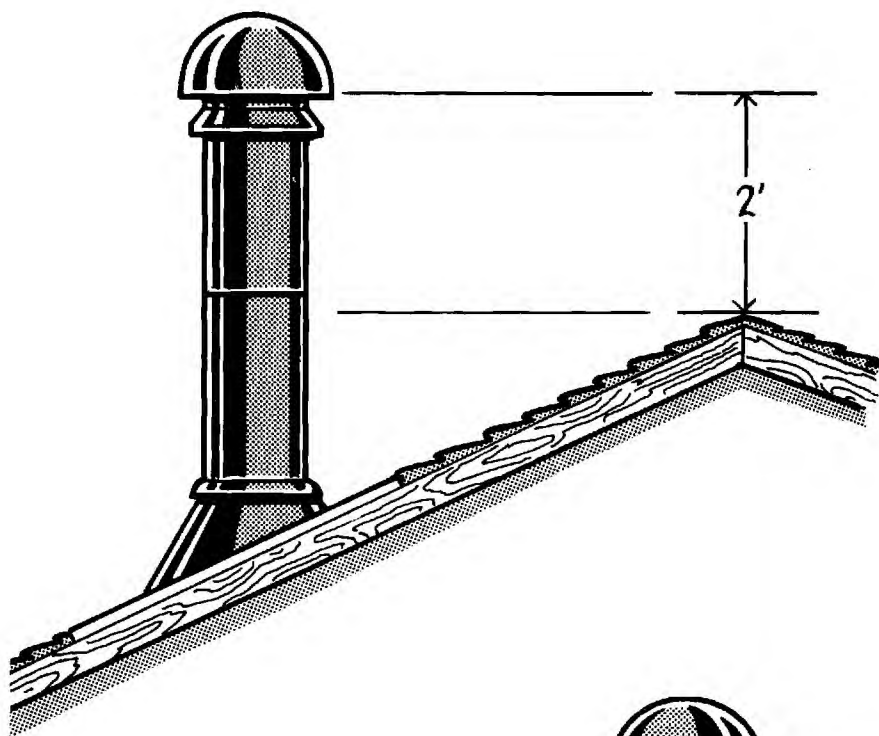
$$(5/12 \times 6') + 2'0'' = 4'6'' \text{ height over roof}$$



Check the manufacturer's instructions carefully; a brace may be needed for heights exceeding 4 feet. Finally, a chimney cap is added to keep out rain and help prevent downdrafts.

Remember, stovepipes and metal chimneys are not the same. Single wall stovepipes may NOT pass through a ceiling or attic. They only connect the stove to the masonry or Class "A" metal chimney.

Many houses have old chimneys that are in good structural shape, but do not meet present Class "A" requirements. A typical example is a chimney constructed of 4" brick without a tile liner. These chimneys can be converted to a safe installation by lining them with 24 gage (or thicker) galvanized duct for 6" diameter and 22 gage (or thicker) for 8" diameter flues. Many flues are not straight and may be impossible to line. As with the chimney connector, the crimped end should be installed **downward** to drain all creosote and condensed water back to the heater.



Single wall chimneys are not allowed inside a house and are rarely acceptable on the outside. These steel "smokestacks" are usually found only on commercial applications and require proper foundations and support. Smokestacks are not recommended because they have an inherent problem with wood fuel: they promote creosote formation by rapid heat loss from the pipe wall. Smokestack or lining installations are not always allowed. Check local building codes, and use accepted Class "A" construction wherever possible.

## **A Final Word On Stovepipes and Chimneys**

In planning your installation, keep in mind that the most trouble-free system will have few, if any, horizontal stovepipes and elbows. A vertical chimney and stovepipe gives the best possible draft and allows creosote and soot to fall back into the stove to be burned. Cleaning this type of system is extremely easy. It generally is lowest in cost because elbows and tees are more expensive than straight stovepipe and chimney. Finally, long runs of horizontal stovepipe inevitably fill up with soot, ash, and creosote and should be avoided.



# Operating Your Stove System

## Fire It Up

There are many ways to build a fire. The basic principle is to set a match to easily ignitable tinder, which ignites the fast-burning kindling, which in turn ignites the slow-burning firewood. Here is one method that works:

1. Place several wads of crushed paper in front of the firebox.
2. Lay small dry sticks of kindling on top.
3. Open dampers fully.
4. Clear the immediate area of combustibles such as matches, cloth, and newspaper. Make sure the room is adequately ventilated and the flue is unobstructed.
5. To prevent smoking on initial lighting, induce a draft by holding a lighted newspaper as near as possible to the flue outlet or slightly open a window in the stove room.
6. Light the wadded paper in the stove and close the stove door. *Don't ever light or rekindle a stove fire with kerosene, gasoline, or charcoal lighter fluid; results can be fatal.*



7. Once the kindling is burning briskly, add several full length logs three to four inches in diameter. Be careful not to smother the fire. Stack the pieces of wood at angles — near enough to keep each other hot, but far enough away to allow adequate air flow between them.
8. When ready to reload the stove, add more logs. Large logs burn slowly, holding a fire longer. Small logs burn fast and hot, giving quick heat.
9. Adjust the draft control; the more you close down the control, the lower and slower the fire will burn. Experiment to determine the proper setting. A more open draft control will be needed if you have (a) wet or green wood, (b) no wind outside, (c) cold outdoor temperatures, or (d) a drafty house. For automatic stoves, see the operating handbook — you may have to calibrate your thermostat at the beginning of each heating season.

As long as there are hot coals, repeating steps 8 and 9 will enable you to maintain a continuous fire throughout the season. A note of caution: Most manufacturers of cast iron stoves recommend keeping the first fires small to break in new stoves gradually. New stoves always smoke on start-up as the paint and sealants are heated. Be prepared to open windows and doors for ventilation.

## Do It Safely

- When refueling, open the damper and air inlet fully a minute before opening and loading door. This insures that smoke and combustible gases will not escape into the room. For airtight stoves, this is especially important: a sudden rush of air into the fire chamber can trigger a small slow explosion known as backpuffing. Escaping gases can seriously burn anyone nearby. *All openings in operating stoves should be opened slowly, and the operator's face should be kept well back from the stove for a few moments afterwards.*
- Don't overfire the stove. Red hot stovepipes and overheated flues can cause chimney fires.
- Watch out for handles and surfaces *too hot to touch with bare hands.* Some stove manufacturers supply small metal rods with hooks to operate the handles. But it is always a good idea to keep a glove nearby. Teach children to stay back away from the stove.
- Before going to bed or leaving the house, always check to see that the stovepipe damper is open, the stove door securely fastened, and combustibles a safe distance from the stove.
- Ashes that seem cool may contain concealed hot embers, so always place ashes in a metal container with a tight fitting lid. (Leave an inch or more of ashes to protect the bottom of the firebox.) Place the container on a noncombustible floor or on the ground, away from combustible materials until final disposal.
- Don't burn trash. Chemicals in plastics and other man-made materials can corrode interior surfaces necessitating frequent and costly replacement.

- Do not put green or wet wood on top of the stove to dry it. Such a practice is very dangerous. In fact, do not put anything on top of the stove unless it is absolutely fireproof.
- Do not store flammable liquids near the stove especially in workshops, basements, and garages.

## An Ounce of Prevention

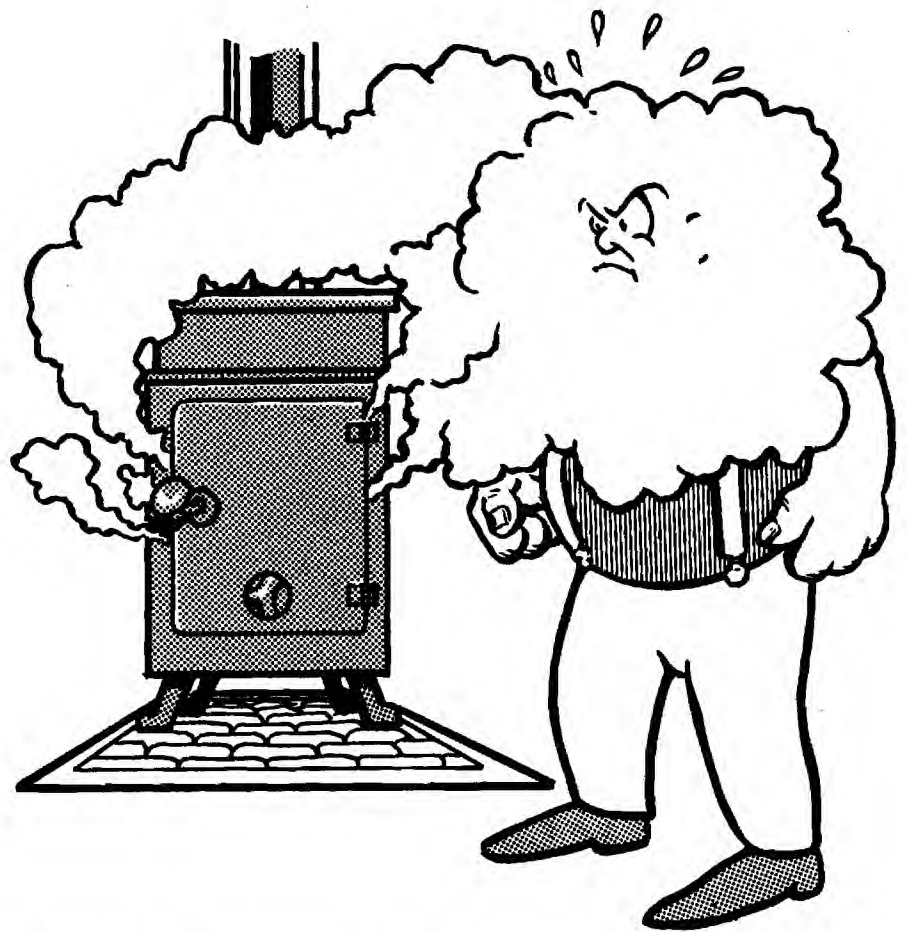
- A fire extinguisher should be mounted in any room with a woodstove. Locate it in the path of exit travel so there's an escape route if the fire cannot be controlled. Inspect each extinguisher at least once a month.
- Keep a bucket of sand nearby. It is especially helpful in slowing down or extinguishing the fire in a woodstove. Use water on woodstove fires *only in extreme emergencies*: the water turns to steam, scatters hot ash everywhere, and can crack cast iron stove parts.
- Install smoke detectors, especially if your stove provides heat all night long. According to NFPA, the majority of fatal residential fires strike between 9 p.m. and 6 a.m. when people are asleep.
- Burning well-seasoned dry wood will keep creosote deposits to a minimum.

*Woodstove users must commit themselves to a fire-safe lifestyle.*

## Oh, No, It Smokes!

Jay Shelton gives some basic remedies for smoking stoves in his *Woodburners Encyclopedia*. First, make sure the dampers are not shut and adjust house openings as follows:

- Open windows or doors a crack at the first floor or basement, on the windward side if weather is windy.
- Close windows or doors on the upper floors of the house.



If the stove only smokes in windy weather, install a chimney cap if there isn't one, install a better chimney cap if there is one, or increase the height of the chimney.

If chronic smoking is a problem even in calmer weather:

1. Check the entire venting system for obstructions and clean if necessary. Birds' nests and creosote are possible causes of blockage. Overhanging trees may also cause downdrafts.
2. Make sure the stovepipe is not inserted too far into the flue opening.
3. Try opening a window or door in the same room as the stove; if smoking stops, direct feeding of outdoor air to the woodstove's vicinity may help.

4. Try moving the stove closer to the chimney and eliminating elbows in the stovepipe connector.

5. Weatherstripping and sealing upper floor windows and attic doors can help.

6. If more than one flue is connected to the chimney with flue openings directly opposite, raise or lower one of the openings. Each woodburning appliance should have its own chimney.

7. Last resort is to get a smaller stove or increase the diameter of the chimney.

## Watch Out For Chimney Fires

When combustion is incomplete, hot unburned gases and tar-like liquids go up the flue with the smoke. As these substances contact cooler surfaces, they condense much like water droplets on a glass containing an iced drink. When the water evaporates, it leaves behind a tar that builds up fire after fire into a crusty black layer called creosote.

Chimney fires occur when creosote on the inside of a chimney wall burns. Chimney fires are most likely to occur during a very hot fire as when cardboard is burned or when normal wood is burned at a very high rate. A crackling sound is often heard at the beginning. As intensity grows, the stovepipe may shake violently, air will be forcefully drawn in through the stove, and the stovepipe will glow red hot. A tall plume of flame and sparks will rise from the top of uncapped chimneys.

When a chimney fire starts:

1. Close the dampers. This limits the air supply to the fire.
2. Call the fire department if the fire doesn't go out immediately.
3. Wet down the roof and other outside combustibles to prevent fires started by shooting sparks and flames.
4. Keep a close watch on all surfaces near the chimney.

Properly installed and well maintained stovepipes and chimneys are intended to withstand an occasional chimney fire, but this is a dangerous method to keep a chimney clean. There is always the risk of a house fire, and a chimney fire encourages cracking and corrosion of the flue.

To cut down on creosote deposits:

- Burn dry well-seasoned hardwood.
- Keep a briskly burning fire; maintain a good draft.
- Add small loads of wood frequently rather than fewer large loads.
- Minimize the length of stovepipe connecting the stove to the chimney.
- Use the woodstove consistently without much time lapse between fires.

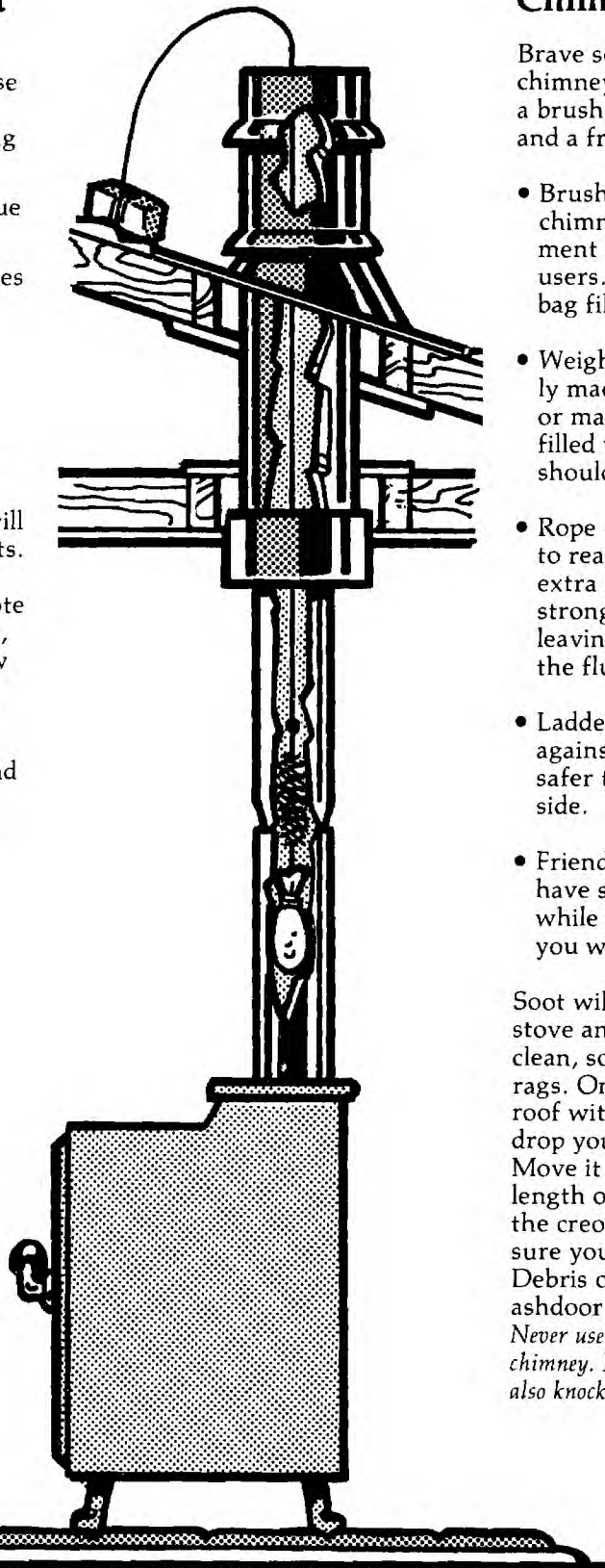
# Cleaning Your Stove System

## Creosote Is The Culprit

Removing creosote on a regular schedule is very important because

- 1) It acts like an insulator reducing heat transfer efficiency.
- 2) Large deposits can block the flue making the stove smoke.
- 3) It is highly flammable and causes dangerous chimney fires.

One-quarter inch of creosote buildup signals cleaning time, according to chimney sweeps Christopher Curtis and Donald Post. Inspect the flue at both the stove end and chimney top. Remember that cooler surfaces will have the thickest creosote deposits. Also, it is unfortunate, but the efficient airtights generate creosote much faster because of their long, slow burning characteristics. New stove installations should be inspected every few weeks until you determine creosote build-up rates. New truckloads of wood and switching from heavy heating (winter) to light heating (spring) can affect the rate too.



## Chimneys First

Brave souls will elect to clean their chimneys from the roof. You'll need a brush, a weight, a rope, a ladder, and a friend.

- Brush — a quality steel bristled chimney brush is a good investment for serious woodstove users. You can also try a burlap bag filled with sand.
- Weight — buy a weight specifically made for your chimney brush or make your own from a can filled with rocks. Twenty pounds should be sufficient.
- Rope — it should be long enough to reach the bottom (plus a few extra feet for safekeeping) and strong enough not to break, leaving brush and weight stuck in the flue.
- Ladder — resting the ladder against the roof peak or eave is safer than against the sloping side.
- Friend — as a safety precaution, have someone hold the ladder while you climb and watch while you work.

Soot will tend to puff out of the stove and into the room while you clean, so plug the stovepipe with rags. Once you are safely on the roof with equipment ready to go, drop your brush down the flue. Move it up and down the entire length of the chimney, scraping off the creosote deposits until you're sure you have a "clean" chimney. Debris can be shoveled out at the ashdoor or at the stovepipe. Note: *Never use tire chains to clean a masonry chimney. It not only knocks out creosote, it also knocks out bricks and mortar.*

There is another cleaning method that doesn't require climbing the roof. You'll need a flue brush and flexible extension handles from your local stove shop. Lay a drop cloth around the stove area to protect carpeting from soot. Carefully remove the stovepipe, marking each joint if you take it apart. Set up a cardboard box or old sheet at the flue opening in the wall to catch the soot and creosote. Attach the handle to the flue brush and push it into the flue. Work the brush up towards the top of the chimney adding extensions as required. Move the brush up and down the flue until no more creosote falls to the bottom. Collect the debris and toss it into the trash.

## Then Pipes and Stoves

Cleaning pipes and stoves is a messy job best done outdoors if possible. You'll need a flashlight, a wire brush, a dust pan, and a whisk broom. Make sure the pipe and stove are *cold* before starting.

Mark all joints of the stovepipe. This will make reassembly much easier. Remove the stovepipe carefully and put it in a cardboard box to keep soot from falling where it doesn't belong. Once you have the pipe outdoors, take it apart. Use the brush to scrape off deposits from the inside of each section. Replace any that are excessively corroded and reassemble using your marks as a guide.

Move the stove outside or cover the floor with a drop cloth. Shovel the ashes or sand into a bucket. Use the flashlight to see what the interior looks like. Then reach inside with your wire brush and scrub away. If you have a baffle system, this should be cleaned too. Remove the loose deposits with broom and dust pan. Now use the flashlight again to inspect very carefully for cracks and corrosion. If cracks are small, seal them with furnace cement. If cracks are large or on movable parts, it's best to have them welded. Don't forget to replace the protective layer of ashes or sand.

Most stove owners like to keep the exterior looking new. Use a high temperature paint; it will prevent rust from spreading and will increase the radiant qualities by covering shiny spots. The more modern enamel cabinets can be cleaned with soap and water. Make sure the stove is cold.

## Test It For Leaks

When chimney, pipe, and stove are clean and back in place, conduct a smoke test to find any cracks. Send someone to the roof with a wet blanket while you light a small, smoky fire in the stove. Cover the chimney top with the blanket and look for leaking smoke. Have cracks repaired immediately to insure a safe, efficient heating system.



# Finding The Wood

## Look Around You

Firewood is very plentiful if you know where to look. The U.S. Forest Service permits the cutting of firewood for personal use in designated areas of the National Forests. Prior to cutting, obtain a permit from the District Ranger's office covering that area. The permit will state what, where, when, and how much you are permitted to cut.

Landowners can benefit by using or selling firewood on their tracts. Many small woodlots contain trees that are not profitable for commercial use such as undesirable species and diseased, forked, or crowded trees. Removing these trees upgrades the forest stand for future timber sale and at the same time produces income that would otherwise be lost. A professional forester, state or private, can advise the landowner on which trees to remove.

Normal logging operations leave behind excess logging slash (limbs and tops) unsuitable for commercial use. It can be unsightly and pose a wildfire hazard. Logging slash is often the right size for firewood or kindling, needing little or no splitting. Firewood seekers are sometimes allowed to cut or purchase the downed slash. Contact the individual landowner or company representative for permission.

Right-of-way clearings or new construction sites are also good places to get firewood. Obtain permission from the owner or contractor before cutting.

Occasionally, timber and paper companies will permit individuals seeking firewood to cut designated trees in designated areas. Prior to entering the area, get permission from the company.

Firewood has become a source of income for some individuals. They offer wood for sale that has been cut, split, and dried, and often will deliver it to your home. Check your local newspaper or yellow pages under "Firewood."

To reduce the solid waste deposits, some county landfills may be willing to give you wood that is suitable for burning. Other sources are lumberyards and crating operations. Give them a call and find out.

## Get Your Money's Worth

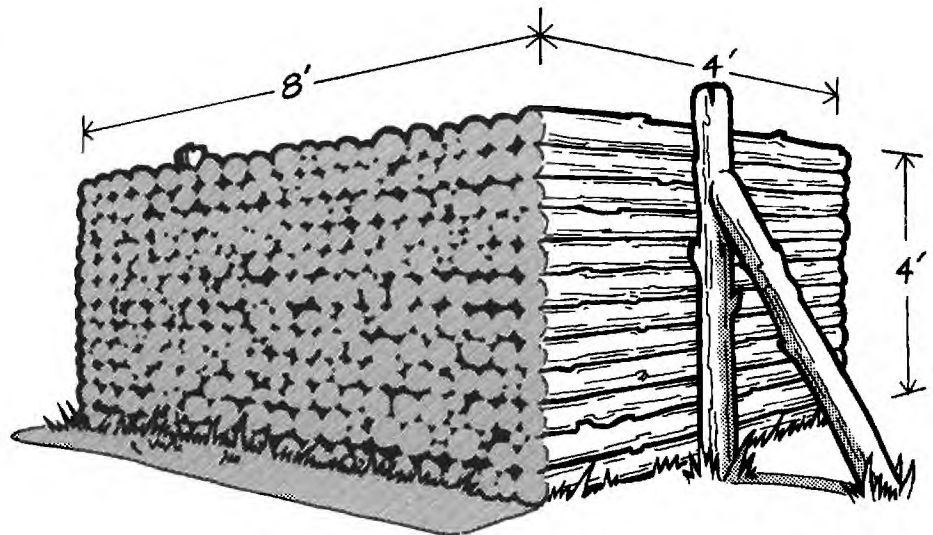
- Know your species. Hardwood should cost more than softwood.

- Measure your wood properly. Remember: 1 cord = 128 cu. ft. =  $4' \times 4' \times 8'$ . A rick is a half cord if cut in 2' lengths, a quarter cord if cut in 1' lengths. A pickup truck load is one quarter to one half a full cord.

- Seasoned wood is worth more than green wood.
- Get the landowner's permission before cutting wood.
- Know where the property boundaries are.
- If you are on someone else's land, treat it as though it belonged to you. You might want to return.
- Know which trees to cut.

For assistance in buying or selling firewood, contact your local county forestry unit.

A CORD =  $4' \times 4' \times 8' = 128$  CUBIC FEET



## Cutting The Wood

According to a 1974 survey, 86% of the woods accidents were related to unsafe practices. The majority of these accidents resulted from loading wood and using chainsaws. Contributing to loading accidents were broken hands and feet, cuts, strains, and sprains. Chainsaw accidents resulted in cuts to the legs, hands, arms, and face. The following are some general safety tips to aid you while cutting wood.

### Wear Protective Clothing

Proper clothing is just as important to your safety as knowing how to fell a tree. The following should be worn when working in the forest.

- Hard hat
- Safety goggles
- Comfortable but trim fitting clothes
- Work gloves
- Hard toe shoes with non-skid soles
- Ear plugs — when exposed to prolonged chainsaw noise.

Be prepared and plan ahead. You should carry the following items to the woods with you.

- Drinking water
- Snacks (candy is good for an energy boost as is cheese or other high protein food)
- Tools needed for saw sharpening and minor repairs
- First aid kit

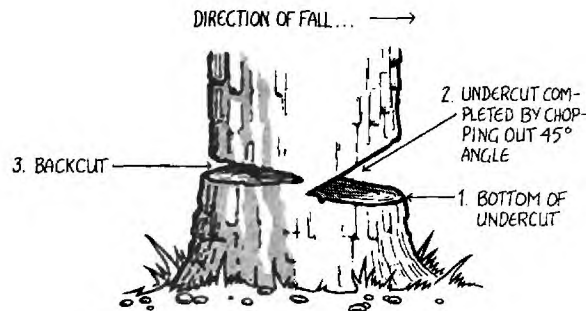
### Respect Your Chainsaw

Before using your saw, get to know it well. Read the owner's manual from cover to cover.

1. When carrying a chainsaw any distance, be sure that you carry it by the handle with the motor off and the guide bar to the rear.
2. Never attempt to start a chainsaw on your knee or in the air. Start the saw on solid ground that has been cleared to mineral soil.
3. When moving from tree to tree with the saw, make sure the chain is not moving and your finger is not on the saw trigger.
4. Allow the saw to cool before refilling with gasoline. Refuel the saw in an area that has been cleared to mineral soil. Carry all gasoline in approved safety cans.
5. Before restarting the saw, be sure that all gasoline spills have been wiped off.
6. Take frequent rest breaks to avoid dizziness from prolonged exposure to noise and loss of hand coordination from chainsaw vibration.

### Know Your Logging Basics

1. Before felling, check the top of the tree to see if widow-makers (broken or dead limbs) are present.
2. Clear the area around the base of the tree and make sure that surrounding brush will not hinder your line of retreat.
3. An undercut should be made on all trees and should be at least one-third of the diameter through.
4. The back cut or felling cut should be at least 2 inches higher than the undercut and never made completely through the line. Leave approximately 2 inches of wood between the cuts for a hinge; otherwise the tree may kick back. If the tree does not fall, use wedges to topple it in the right direction.

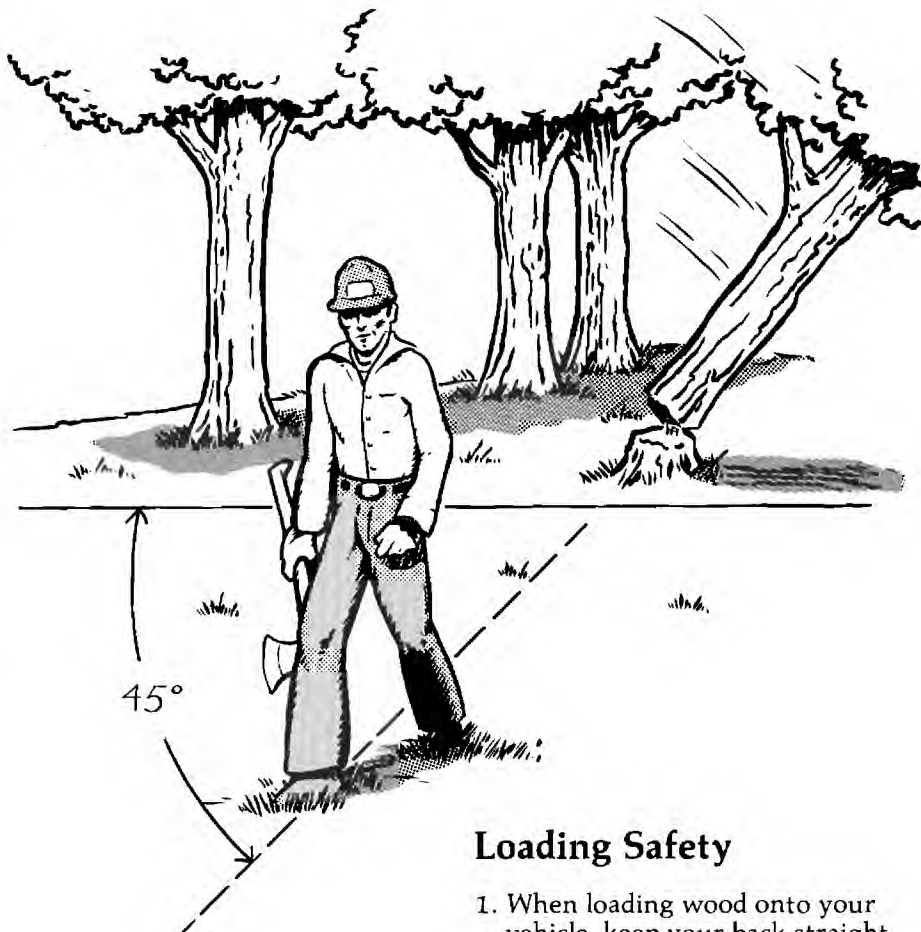




5. When the tree begins to fall, move away at a 45 degree angle from the fall of the tree.
6. If a tree becomes lodged in surrounding trees, do not try to dislodge it by climbing or by cutting a section out of it. Try to pull it down with the aid of a truck or tractor.
7. Never attempt to fell trees on windy days.

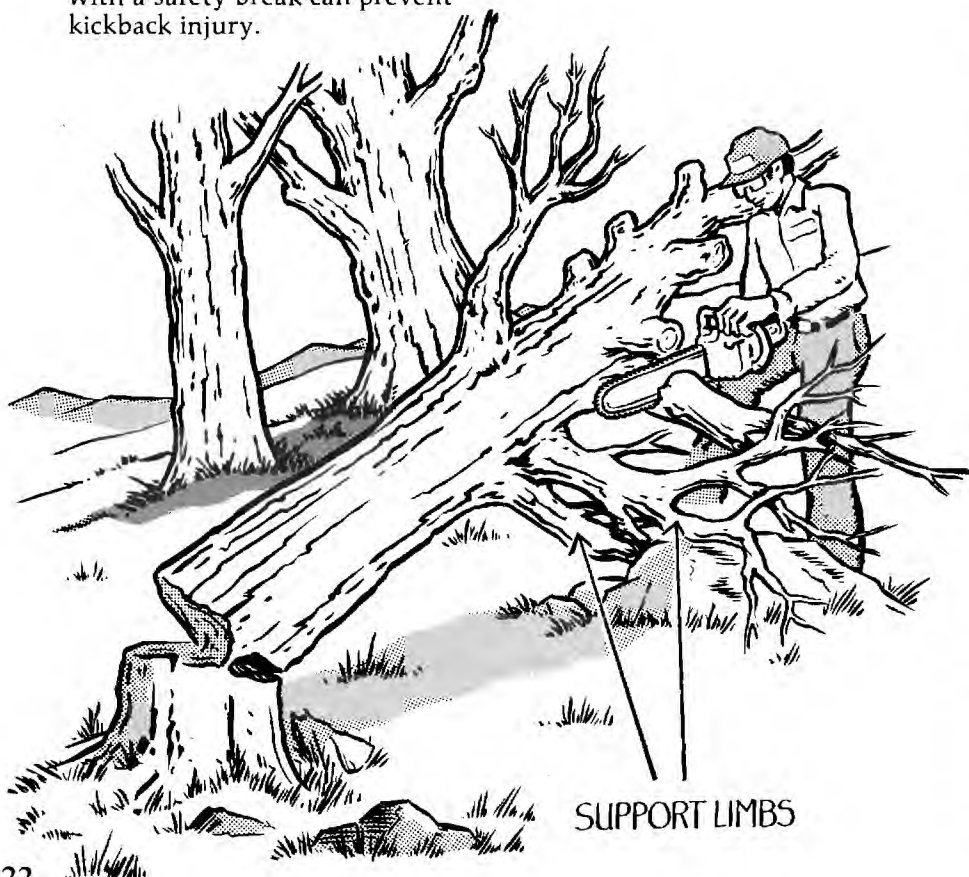
Most accidents involving chainsaws occur during the limbing and bucking process. Kickback is the most common accident.

1. Never attempt to limb or buck while standing on the downed tree. Stand on the ground and make sure that your footing is sound.
2. When limbing or bucking, start at the butt end working your way to the top. Stand on the opposite side of the tree from the limb you're cutting.
3. Cut any support limbs with extreme caution and always stand on the uphill side.
4. Never use the tip of the saw for limbing or bucking. A chainsaw with a safety break can prevent kickback injury.



## Loading Safety

1. When loading wood onto your vehicle, keep your back straight and lift with your leg muscles.
2. Tumbling or rolling heavier pieces is much easier than trying to carry them.
3. Never overload your truck or trailer.
4. Before leaving the woods, make sure your load is stacked properly and balanced to avoid dangerous load shifts on the road.
5. Check your brakes after you are underway to get the feel of the load and the stopping distance. Make sure your tires are inflated to carry the extra load.
6. Drive defensively and avoid speeding.



Once you get the wood home, split it and stack it for three to six months of seasoning. Use a row of cement blocks to keep the bottom logs from absorbing ground moisture and rotting. A roof overhead will keep rain off; but don't enclose the stack entirely, as good air flow through the stack is required to dry the wood to a 20% moisture content before burning.

# Growing The Wood

Owning a woodlot can provide you with a source of wood for your own stove and a little extra to sell to others. One cord per acre per year is a good average here in the South, assuming you begin with well-stocked stands and manage wisely. But why manage; doesn't nature take care of itself?

Forest management can ensure a healthier and more desirable stand of trees, a stand of greatly improved value. What you receive from a well-managed forest will depend upon you and your objectives — current or future income, wildlife habitat, recreation area, something to leave to your family, or a supply of fuelwood for your stove. Forest management is not as complicated as it may seem. State, federal, or private foresters can advise you on all aspects of forestry including fire, disease, and insect control; and they are trained to help you develop sound management practices.

## A Plan of Action

As in any business, to reach a desired goal you must first have a plan of action. A forester will make a field examination and establish this plan for you. The general points that should be covered are:

1. Existing species
2. Estimated volume of wood
3. Stand condition
  - a. Growth rate of trees
  - b. Major problems with insects or disease
  - c. Overstocked, understocked, or well-stocked
  - d. Potential fire hazards
4. Areas in need of planting
  - a. Recommended species
  - b. Method of planting
  - c. Site preparation

5. Recommendations on harvesting
  - a. When to cut
  - b. How much to cut
  - c. What method to use
6. Projections of future volume

## Planting

Any land can be productive. Open land that is growing weeds, brush, or scrub trees can start working for you if you plant trees.

Site preparation will ensure maximum seedling survival. Depending upon existing conditions, site preparation can range from prescribed burning (a good management tool to be used by qualified persons only) to the use of heavy bulldozing equipment. Your forester will advise you on the method.

In planting, you must select a species suited to your area. A crop of trees can be grown from seeds cast by existing trees or scattered by hand. The other alternative is to plant nursery-grown seedlings.

## Harvesting

Harvesting may be a controversial matter to some. By not harvesting, you allow valuable mature trees to die and force healthy trees to compete with less desirable specimens for precious space, food, water, and sunlight.

There are three common types of harvesting.

1. *Selective thinning*: The main purpose behind this method is to remove the "bad" trees leaving the "good" trees for future growth and stand improvement. Trees marked for cutting should include overmature, crowded, insect or disease infested, crooked, and forked trees as well as undesirable species.
2. *Seed Tree*: This practice is used mostly in pine forests. All trees are harvested except those selected to remain because of their superior characteristics to reseed the area naturally. Six to eight trees per acre are enough to grow a new forest.
3. *Clearcut*: This is the removal of all saleable timber from a given area. Whenever a clearcut harvest is made, it should *always* be followed by a plan for regeneration.

There is no right or wrong harvesting method. A forester can assist you in choosing the best one for you and your land.

## Selling

Two common ways of selling timber are volume and lump sum sales. On volume sales, you receive payment for what is actually cut from your land. On lump sum sales, you receive payment based on the estimated volume for removal. Tax advantages and market demand will determine which is best suited for you.

Trees that are classified as sawtimber are sold on a thousand-board-foot (MBF) basis. There are three separate log rules used to determine the volume of a tree — Doyle, Scribner, and International. Prior to selling, make sure you know which was used to determine the volume on your land and which your timber is being bought or sold on.

Pulpwood trees are sold on a cord (128 cubic feet) or weight basis. Fuelwood is sold on a cord basis.

## **Money Matters**

The cost of good forest management will vary depending upon your needs and objectives. Your state foresters can assist you on a little or no fee basis. Cost sharing programs are available through the federal government to help landowners on seedling purchases, site preparation, tree planting, and TSI (Timber Stand Improvement). Your county forester can give you additional information concerning these programs. Tax benefits are also available to forest landowners. Be sure to check out your situation before completing any business transactions.

## **Small Woodlots**

Landowners with holdings too small to finance massive timber operations can still benefit from the basic principles of forest management. Watch for disease and insects — don't let them spread to healthy trees. Know which trees are best to cut now and which are best left to grow. Plant new trees to fill in large voids.

Forest management has proven worthwhile to many landowners. Are you working for the land or is the land working for you? Remember, trees are America's renewable resource.

# Burning the Wood

## Basics of Burning

Woodburning or combustion is the mixing of carbon and hydrogen from the wood with oxygen from the air to form carbon dioxide and water and release heat. Combustion has three requirements — fuel, air, and heat. If any of these three are removed, burning ceases. When all three are available in the correct amounts, combustion is self-sustaining because the fuel releases more than enough heat to initiate further burning.

The rate at which wood burns is controlled by the amount of air available. The air-fuel ratio is defined as the amount of air to the amount of fuel used in combustion. There are limits on the amount of air under which combustion can proceed. With little or no air, there is insufficient oxygen to combine with the fuel and combustion stops. Too much air will cool the fire, remove the heat, or in essence blow the fire out. Typically combustion proceeds best with a slightly excessive amount of air. Most stoves are designed with controls to provide air in the proper range of air-fuel ratios for good combustion.

### • COMBUSTION PRODUCTS •

CARBON DIOXIDE  
• WATER •  
• HEAT •



HEAT  
+  
AIR  
+  
FUEL

### REQUIREMENTS FOR BURNING

Another important aspect of combustion is the heating value of the fuel. Heating value is a measure of the available chemical energy per pound and is expressed numerically in Btu per pound. Table IV shows relative heating values for several common fuels. Wood has a low heating value, meaning it is not a concentrated source of energy.

TABLE IV  
Heating Values of Common Fuels

Fuel	Heating Value (Btu/lb)
Wood (Wet)	4,500
Wood (Dry)	8,840
Coal	13,000
#2 Fuel Oil	19,750
Gasoline	20,700
Natural Gas	22,800

Combustion efficiency, related to heating value, is a very important aspect of stove operation. Combustion efficiency is the percentage of the available chemical energy (heating value) converted to useful heat. Combustion efficiency is dependent on three parameters — turbulence, temperature, and time.

Turbulence indicates the degree of mixing between wood and air in the combustion zone. Complete combustion requires that there be adequate oxygen to combine with each fuel molecule. Turbulence in the combustion zone reduces the amount of unburned fuel by encouraging contact between fuel and air.

Every combustible substance has a minimum ignition temperature that must be maintained if combustion is to start and continue. If the temperature drops, combustion is hampered or may cease entirely. Sufficient temperature to assure complete combustion in a woodstove can be maintained several ways:

- Lining a stove with firebrick to keep heat in
- Preheating combustion air
- Recirculating flue gases

Since chemical reactions proceed at different rates, not only must mixing and heat be adequate, but sufficient time must be provided for the combustion reaction to be completed. If residence time in the combustion zone is inadequate, combustion efficiency will be adversely affected. Certain stove flow patterns such as the "cross" or "S" flow increase resistance time and promote turbulence, both of which improve combustion efficiency.

## COMPLETE COMBUSTION REQUIRES

TIME



+

TEMPERATURE



+

TURBULENCE



3T'S



**TABLE V**  
**Relation Between Available Heat and Density**

Species	Density (lb/ft <sup>3</sup> )	Heating Value (Btu/lb)	Available Heat Per Air Dried Cord (million Btu/cord)
White Oak	48	8,810	23.9
Yellow Pine	41	9,610	22.0
Red Oak	42	8,690	21.7
White Pine	26	8,910	14.2

## Words On Wood

Properties of the fuel play a prominent part in burning, and wood is no exception. The important properties of wood that affect combustion are species and moisture content.

Wood species affects combustion because density is species dependent. The available heat or heating value from a pound of any wood is about the same. However, wood is sold by volume; therefore, the density of the wood, not the heating value, is most important in establishing the available energy in a cord. The wood species in Table V are ranked in order of decreasing available heat per air-dried cord. Note how a dense wood like white oak has more energy per cord than a light wood like white pine even though their heating values are about the same.

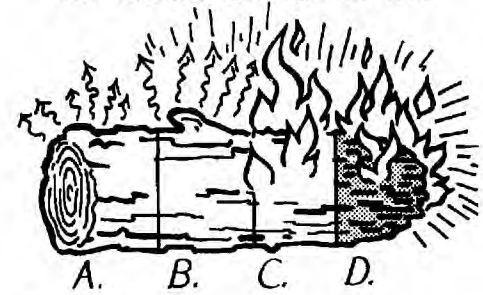
Burning rate and heating value are affected by moisture content. Everyone is familiar with the difficulty of burning green wood versus seasoned or dry wood. Moisture content is how the "wetness" or "dryness" of wood is measured. The moisture content of green wood as cut in the forest can be as high as 50%. This means that up to one-half of the wood's weight is water. Moisture content is dependent on species, where the tree grows, and which part is burned. Green wood that is air-dried in four to six months decreases in moisture content to around 20%. Dried or seasoned wood starts burning easier and burns better once started.

## Wood Burns in Four Stages

The surface of the wood does not ignite directly on heating, but first undergoes thermal breakdown — resulting in vapors, gases, and mists — some of which are combustible. The first stage or zone of combustion exists up to 395° F. In this zone there is a slow, steady weight loss as water vapor and other non-ignitable gases are driven off. In Zone B (temperature range 395° to 535° F) more gases are driven off, and reactions first occur to liberate heat. However, there is no flaming until higher temperatures are reached. The temperatures in Zone C range from 535° F to 935° F. In this zone gases continue to evolve and react giving heat. At first, they are too rich in carbon dioxide and water vapor to sustain flame, but secondary reactions occur forming combustible gases which ignite and flame. Finally, all the gases and tars are driven from the wood, and pure carbon (usually referred to as charcoal) remains. Combustion of the charcoal occurs in Zone D and the temperature of the wood surface rises above 935° F. Since all four stages of combustion occur simultaneously, many secondary reactions result which further complicates combustion.



## FOUR STAGES OF WOOD COMBUSTION



## More On Creosote

Ideally wood combustion is complete, and the products are carbon dioxide and water. In reality, combustion is never complete. Smoke is evidence of this since it is made of unburned fuel — combustible gases, liquid droplets, and solid particulates. Part of the organic compounds in smoke often condense in the chimney or flue pipe. This tar-like substance is called creosote. If the combustion zone temperature is sufficiently high, creosote burns along with the other organic compounds in the wood. However, creosote burns at a higher temperature than other chemicals in the wood. Thus, there are times when the other products burn but creosote does not.

The amount of creosote formed depends on the density of the smoke rising from the fire and the temperature of the surface onto which it condenses. Smoke production is greatest when fresh wood is added or when air supply is turned down low. When a fresh charge is added to the stove, heat will be subtracted from the combustion zone to warm the wood. Since the temperature in the combustion zone is lowered, combustion is not as complete and smoking results. As a remedy, smaller pieces of wood can be added or more air can be admitted to increase the burning rate of the existing wood and quickly ignite the fresh wood.

**WHERE THERE'S SMOKE,  
THERE'S CREOSOTE!**

**TABLE VI**  
**Stages of Wood Combustion**

Zone	Temperature	Reaction
A	Below 395° F	Water and noncombustible gases given off
B	395° F to 535° F	Both combustible and noncombustible gases given off, slight reaction to give off heat but no flaming
C	535° F to 900° F	Gases given off become ignitable and flaming occurs
D	Above 900° F	All gases and tars have been given off and remaining charcoal glows

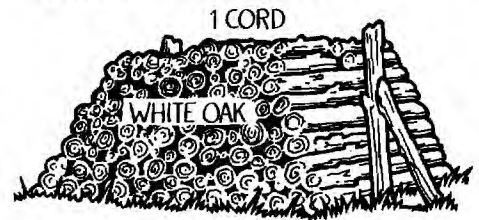
A similar condition exists at night when air flow is restricted to limit combustion and extend the available fuel. Combustion temperatures are lowered and smoke production increases. More air can be admitted to raise the stove temperature, but the fuel will be more quickly consumed. These examples imply that control of smoke production and creosote formation requires detailed attention to stove operating conditions.

Adding a full charge of green wood before bedtime and turning the damper way down will generate large amounts of creosote. Instead, add the last charge of wood to the stove about an hour before retiring. In this way, the wood will be reduced to cleaner burning charcoal.

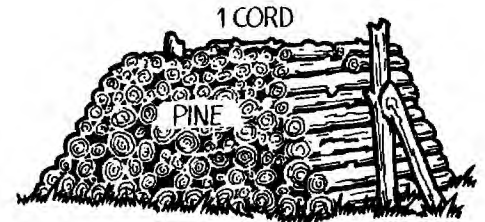
Since creosote is transported mostly as gases, deposits can be limited by preventing condensation on flue pipes. This involves insulating flue pipes to restrict heat loss thus maintaining the temperature of the flue gases. Addition of secondary air to promote creosote combustion above the grate has been suggested. Research has shown that adequate combustion oxygen was available in the flue gas for combustion, but flue gas temperatures were too low to burn the creosote. Addition of more air lowered the temperature still further and did not seem to enhance creosote burning.

Creosote formation is also a function of wood species and moisture content. High moisture content woods tend to have lower combustion zone temperatures caused by the heat used to evaporate the water. The resulting low flue gas temperature allows creosote to condense out on chimney surfaces. Water vapor from unseasoned wood dilutes the combustible gases inhibiting combustion thus increasing smoke and creosote formation. Increased levels of creosote are associated with soft woods because of their high resin contents. While no wood can be burned free of creosote, dry hardwoods have a reputation for generating the least amount.

### AVAILABLE HEAT OF WOOD



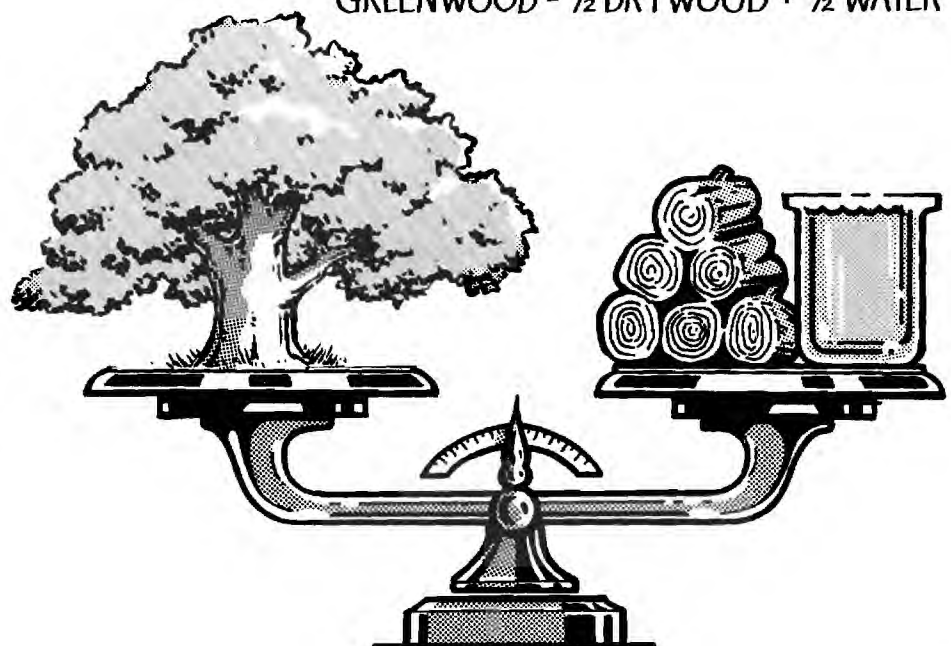
1 CORD  
AIR-DRIED 3620 lbs. = 23.9 mm Btu



1 CORD  
AIR-DRIED 2120 lbs. = 14.2 mm Btu

### MOISTURE CONTENT OF WOOD

$$\text{GREENWOOD} = \frac{1}{2} \text{ DRYWOOD} + \frac{1}{2} \text{ WATER}$$



# Questions and Answers About Woodstoves

**Q. How much wood does a stove use in a 24-hour period?**

A. An airtight stove will use from 14 to 16 hardwood 24" logs, a non-airtight stove considerably more. If you are burning pine or other softwoods, more logs will be consumed.

**Q. Will I have to stoke it during the night?**

A. Most people find this unnecessary as banking the fire and closing the dampers will usually keep the house warm through the night.

**Q. How often do I need to check on the stove?**

A. Every time wood is put in is an appropriate time to do a quick check. When the owner is home during the day, wood is usually added 2 or 3 times. Woodstoves are rarely used when the owners are gone.

**Q. How accurately can the temperature of the stove be controlled?**

A. An airtight stove can be regulated accurately  $\pm 5^{\circ}$  F. The temperature of a non-airtight stove can fluctuate widely, and it is a good idea to have an automatic cutoff on the stovepipe. Some stoves come equipped with an automatic thermostat; these are also accurate to  $\pm 5^{\circ}$  F.

**Q. Where do I get wood?**

A. A little imagination and a little effort can provide you with all the wood necessary to heat your home. Cutting wood from your own property or a friend's property is the most convenient. You can also pick up scrap lumber from new subdivisions or where houses are being torn down. Some people search on the side of the road and follow phone and power company trucks when they cut down trees.

**Q. How much does wood cost per cord?**

A. Price depends on how much of the work you want done for you. To have it delivered cut, split, and stacked in your yard is more expensive than if you pick it up and split it yourself. On the average, wood costs \$40 to \$90 a cord.

**Q. What is the best way to store wood?**

A. Stacked, criss-cross fashion off the bare ground and covered to keep it dry. Season it for 3 to 6 months after cutting.

**Q. Do most people use wood as a primary or as a secondary heat source?**

A. Most woodstove owners keep their gas or electric furnaces in operating order in case of illness or extreme cold weather, even though wood provides a large percentage of their space heat. Homes with no conventional backup systems are generally in rural areas where wood is plentiful.

**Q. What complaints are heard most often about woodstoves?**

A. They take getting used to; an adjustment period is necessary. Initial problems with smoke and lighting the stove are most common, and temperatures fluctuate a good bit until the owner gets to know his own stove.

**Q. How often do I have to check my chimney or stovepipe for creosote buildup? How often do I have to clean it?**

A. On a new installation, check it every 3 to 4 weeks to determine buildup rate. Clean once a season or when a quarter-inch of creosote accumulates. If you're using considerable amounts of pine or green wood, the creosote will build up faster and need checking and cleaning more often.

**Q. How big an area do people try to heat with a woodstove?**

A. Anywhere from 800 to 2200 square feet. How warm you stay will depend on the amount of insulation in the house and the air flow through the house.

**Q. Where do most people place their woodstoves?**

A. In the living room or den — usually the largest room or gathering place for the family.

**Q. How much is really saved on heating bills?**

A. For those people who have converted to wood heat and use it regularly, the savings are 50% or better. Others who have never used anything but wood heat say compared to their neighbors savings are 50% or better also.



**Q. Why do people buy woodstoves?**

A. Most buy because stoves are energy efficient and save on heating bills. Others buy because their families have always had one.

**Q. Does a woodstove contribute extra dirt or ashes in the home?**

A. The only excess dirt is from carrying in wood, but for many people a wood box has solved that problem. If you remember to check each log for wood roaches or ants before you bring it in the house, bug problems can be avoided. Fine ash accumulation in the home can be a sign of bad draft or leaks in the stove system.

**Q. How often is ash disposal necessary?**

A. Anywhere from once a week to once a month, depending on the type of stove you have. Ashes can be used on gardens as a source of potash.

**Q. What precautions can be taken to prevent fires?**

A. Have your chimney inspected by the fire department. A fire extinguisher is a good idea, so is a smoke detector. Extend the hearth. Follow directions from woodstove manufacturers on clearances for installation, and instruct all family members on safe operation of the stove.

**Q. Are there codes or regulations that restrict placement of the stove?**

A. Contrary to popular belief, there are many regulations to follow. Manufacturers instructions or NFPA booklets 89M and 211 are good sources on stove installation. Many counties restrict installation to those units approved by a recognized testing agency such as UL or ICBO.

**Q. Do owners of woodstoves enjoy the atmosphere of woodstoves?**

A. YES. Some people feel woodstoves lack aesthetic appeal, but the money savings are so great that the stove is considered quite valuable and thus enjoyable.

# Reference List for Woodburners

## Firewood and Forests

- FIREWOOD FOR YOUR FIREPLACE. Warren L. Donnelly, 3211 E. Fountain Blvd., Colorado Springs, CO. 80901
- FORESTRY WITHOUT FEAR. Southern Forest Institute, 3395 N.E. Expressway, Suite 380, Atlanta, GA. 30341
- HOW TO SELECT, CUT, AND SEASON GOOD FIREWOOD. John Vivian, Customer Service Dept., Stihl, Inc., P.O. Box 5514, Virginia Beach, VA. 23455
- MANAGING YOUR FAMILY FOREST. Southern Forest Products Association, P.O. Box 52468, New Orleans, LA. 70152
- MANY FOREST LANDOWNERS PAY TOO MUCH INCOME TAX. USDA Forest Service, Southeastern Area, 1720 Peachtree Road, Atlanta, GA. 30307
- SOME USEFUL INFORMATION ON CUTTING AND BURNING WOOD. Office of Energy Resources, 55 Capitol St., Augusta, ME. 04330
- WHAT YOU SHOULD KNOW ABOUT FIREWOOD — BEFORE YOU BUY. Tennessee Valley Authority, Division of Forestry, Fisheries, and Wildlife Development, Norris, TN. 37828
- WOODLANDS FOR PROFIT AND PLEASURE. R. D. Forbes. American Forestry Association, 1619 Massachusetts Ave., Washington, D.C. 20036
- YOUR FORESTLAND: ENJOYMENT, PROFIT. USDA Forest Service, Upper Darby, PA. 19082

## U.S. Department of Agriculture Publications

Address: Superintendent of Documents  
U.S. Government Printing Office  
Washington, D.C. 20250

- FIREPLACES AND CHIMNEYS., No. 1889
- FIREWOOD FOR YOUR FIREPLACE., No. L559
- IS NATURE ALWAYS RIGHT?, No. 1087
- MANAGING THE FAMILY FOREST., No. F2187
- PUBLIC ASSISTANCE FOR FOREST LANDOWNERS., No. PA893
- WHY TSI?, No. PA901

## NFPA Safety Publications

Address: National Fire Protection Association  
470 Atlanta Ave.  
Boston, MA 02210

- CHIMNEYS, FIREPLACES, AND VENTS., No. 211
- HEAT PRODUCING APPLIANCE CLEARANCES., No. 89M
- HOMES, FOREST AREAS., No. 224
- HOUSEHOLD WARNING EQUIPMENT., No. 74
- PORTABLE EXTINGUISHERS., No. 10
- SMOKE, HEAT VENTING., No. 240
- TIMBER, OUTSIDE STORAGE., No. 46
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## Stoves and Chimneys

CHIMNEY AND STOVE CLEANING by C. Curtis and D. Post. Garden Way Association Bulletin A-14, Charlotte, VT. 05445

ENERGY FOR THE HOME by P. Clegg. Garden Way Publishing, Charlotte, VT. 05445

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LOW-COST ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER edited by E. Eccli. Rodale Press, Emmaus, PA. 18049

MODERN AND CLASSIC WOODBURNING STOVES by Bob and Carol Ross. Overlook Press, Woodstock, N.Y.

NEW LOW-COST SOURCES OF ENERGY FOR THE HOME by P. Clegg. Garden Way Publishing Co., Charlotte, VT. 05445

THE WOODBURNERS ENCYCLOPEDIA by J. Shelton and A. Shapiro. Vermont Cross Roads Press, Box 333, Waitsfield, VT. 05673

THE WOODBURNERS HANDBOOK by D. Havens. Harpswell Press, Brunswick, ME.

WOOD HEAT by J. Vivian. Rodale Press, Inc., Emmaus, PA. 18049

WOOD HEATING HANDBOOK by C. Self. Tab Books, Blue Ridge Summit, PA. 17214

THE WOODSTOVE ANNUAL edited by P. McLellan. Society for the Protection of New Hampshire Forests, Concord, N.H.

WOODSTOVE KNOW-HOW by P. Coleman. Garden Way Publishing Co., Charlotte, VT. 05445

## Magazines

ALTERNATIVE SOURCES OF ENERGY. Rt. 2, Milaca, MN. 56353

B&K's COUNTRY JOURNAL. Box 8600, Greenwich, CT. 06830

CANADIAN RENEWABLE ENERGY NEWS. P.O. Box 4869/Station E, Ottawa, Ontario K1S 5B4

FARMSTEAD. Box 392, Blue Hill, ME. 04614

ORGANIC GARDENING & FARMING. Emmaus, PA. 18049

MOTHER EARTH NEWS. Box 70, Hendersonville, N.C. 28739

SOLAR AGE MAGAZINE. Solar Vision, Inc., Box 288, Rt. 515, Vernon, N.J.

WOODBURNING QUARTERLY. 8009 34th Ave., South Minneapolis, MN. 55420

## Directories and Organizations

SPECTRUM: AN ALTERNATE TECHNOLOGY EQUIPMENT DIRECTORY. Alternate Sources of Energy, Rt. 2, Box 90A, Milaca, MN. 56353

WOODSTOVE, FIREPLACE, AND EQUIPMENT DIRECTORY. Box 4474 WR, Manchester, N.H. 03108

WOOD ENERGY INSTITUTE. Box 800, Camden, ME. 04843

Installation specifications in this manual have been taken from NFPA 89M (1976), NFPA 211 (1977), and the Georgia warm air heating standards. With renewed interest in woodburning appliances, safety codes and standards are being revised. Please check with your local code official for changes.

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